In the afternoon the congress again assembled in a general session to hear half a dozen papers on the Panama Canal. Major Pulligny presided at this session. The opening paper by General Goethals reviewed the history of the canal enterprise in much more detail than in his formal address at the morning session. Space may be taken here only for the interesting fact that while the revised estimate of cost of the canal made in December, 1907, was $375,201,500, the total cost of the canal to date, including the $50,000,000 paid to Panama and to the French company and the amounts spent on fortifications, is less than $333,000,000. The remaining papers at this session were by Dr. Emory R. Johnson, on "Commercial and Trade Aspects of the Canal"; Maj. R. E. Wood, on "The Working Force of the Canal"; Maj. F. C. Boggs, on "The Purchase of Supplies"; D. F. MacDonald on "Canal Zone Geology," and F. D. Willson, "Climatology and Hydrology of the Canal."

In the evening a reception was held at the Palace Hotel for all the members of the congress and their ladies.

On Tuesday morning began the separate meetings of the eleven sections of the congress devoted to special fields of engineering.

National Engineering Societies Meet in San Francisco

EDITORIAL CORRESPONDENCE

Engineers from all parts of the United States, with representatives of the profession from foreign countries, began a notable series of meetings in San Francisco on Thursday, Sept. 16.

The American Society of Civil Engineers held its annual convention at the Hotel St. Francis on Thursday morning with some 400 in attendance. President Charles D. Marx, of Stanford University, delivered the annual address, taking as his subject, "Idealism and the Engineer." He urged that the engineer is as truly an idealist as the artist or the poet. Every engineering work must exist in the imagination of some engineer before it can assume physical form. Whoever does his duty at personal risk in a useful work is a hero as truly as those who risk their lives in warfare.

Professor Marx alluded to the fact that the head of the Belgium Relief Commission, Herbert C. Hoover—of whom prominent Belgians have said, "Hoover is the hope of Belgium"—is a member of the Society. Taking illustrations from many different departments of engineering, Professor Marx showed how great works effecting most public benefits were being performed by engineers.

At a brief business meeting following, Secretary Hunt announced that the ballot for the place of holding the summer convention of 1916 had resulted in 118 votes in favor of Pittsburgh, 51 for Boston and 48 for Washington, with many scattering.

The board of direction had recommended that the Society by letter ballot should rescind its action taken some years ago opposing legislation for the licensing of engineers. The result of the ballot showed 2,024 votes to rescind the former action and 592 against rescinding. This vote leaves the board free to act on this matter according to its best judgment.

On Thursday evening a dinner was given by the San Francisco members of the Society to the visiting members.

On Friday afternoon many of the members of the Society and their guests went to Del Monte, where a golf tournament was arranged for the following day and an automobile tour from Santa Cruz to the Big Basin and San José on Sunday.

The American Society of Mechanical Engineers held sessions on Thursday morning and on Friday morning. At the first of these the engineering features of the Panama-Pacific Exposition were reviewed in papers by Guy F. Bayley, Chief Mechanical Engineer of the Exposition, and George W. Dickie, vice-president of the Society. Following this session the visiting members were entertained at luncheon on the exposition grounds.

At the session on Friday morning papers on the heavy-oil engine and the Diesel engine were presented by A. H. Goldingham, Engineer of the De La Vergne Refrigerating Co., of New York, and Prof. W. H. Adams, of Throop Polytechnic Institute, at Pasadena. These papers were discussed by C. R. Weymouth, Chief Engineer of Charles C. Moore & Co., who maintained that under the prevailing conditions of cheap fuel in the United States there were very few places where the Diesel engine could show a commercial success. He stated that the total capacity of Diesel engines now in use in the United States, after a dozen years of attempted exploitation, is only about 100,000 hp., while in steam turbines, single units of 50,000 hp. are already talked of.

A notable social event on Friday was a luncheon given in honor of the president of the Society, Dr. John A. Brashear, by Charles C. Moore, president of the Panama-Pacific Exposition. The invited guests included members of the Society's council and other noted engineers. Dr. Brashear has been named by Governor Brumbaugh of Pennsylvania as the most distinguished citizen of that state, and Wednesday, Sept. 22, was celebrated at the exposition as Brashear Day in his honor.

The American Institute of Electrical Engineers, at a special convention, distinguished itself by dealing with a long list of technical papers, 26 in number, and holding sessions both morning and afternoon on Thursday and Friday. Two and three parallel sessions were held to discuss simultaneously such special subjects as electric transmission, valuation of public utilities and wireless telegraphy. Joint sessions were held with the American Institute of Radio Engineers. The principal social event was a dinner-dance on Thursday evening.

A Pan-American Road Congress, consisting of a joint convention of the American Highway Association and the American Road Builders' Association, was held at Oakland, Sept. 13 to 17. Some 27 papers on various phases of highway construction and maintenance were scheduled for presentation. Considerable interest was aroused in the convention by the proposal brought forward by the Pacific Coast delegates that the Federal Government should construct a national highway along the Pacific Coast from British Columbia to Mexico. After discussion the project was approved in modified form as follows:

Resolved, That the Pan-American Road Congress recommends to the Congress of the United States the advisability of investigating the necessity of building a hard-surfaced highway along the Pacific Coast from Canada to Mexico, and other national highways to be used for military and commercial purposes.

The pacificists and militarists had it out on the insertion of the words "military" in this resolution, with the result shown.

Subway Timbering Accidents; Two New York Streets Fall

Blast Starts Collapse on Seventh Ave. Line

More than a block's length of New York street surface, with a fully loaded street car and several wagons, dropped into the subway excavation underneath on Wednesday, Sept. 22, 1915. The collapse was the indirect result of a regular blast in the bench at the north face of the excavation. It is not only the worst construction accident in the history of the new subway work in New York City, but it has also made the people and the officials of the city suspicious about the safety of all the many miles of timber-supported street surface over subway construction work.

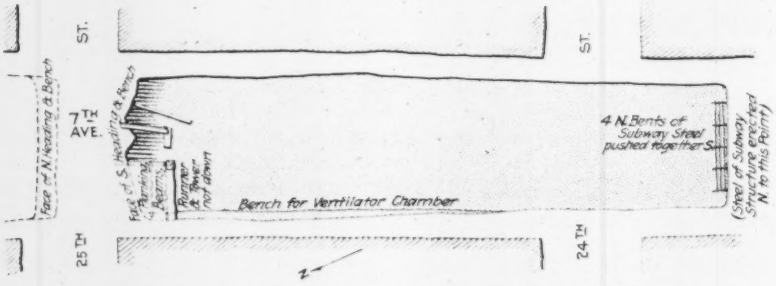


FIG. 1. SKETCH PLAN OF SEVENTH AVE. COLLAPSE

The accident is unexplained. Its origin—a local failure or knocking-down of timbers by flying rock or other effects of the blast—is readily understood. But no explanation has been given by the parties involved of the extension of collapse backward along the completed timbering—presumably secure and solid—for a distance of at least 300 ft., or about 30 bents. Suggestions have been made that some general cause, as a gasoline-vapor explosion set off by the blast, brought about the wreck; these suggestions are only hypothetical, as no facts have been learned to support them.

Subway work in Seventh Ave. extends south from 42nd St. to a connection with a pair of tunnels under the East River at Old Slip. All but the extreme southerly part is four-track structure with all tracks on the same level. The structure is generally as near the surface as the pipe and sewer systems permit.

The collapse occurred in the section from 16th to 50th St., which is being built by the United States Realty and Improvement Co. as contractor. The south end of this section is in sand for the full depth, while the north half is in all rock (schist). The same working system is employed in both parts, with only minor differences. As in all the subway work now going on in the city, the excavation is done underground, after replacing the pavement by planking laid on joists and beams. These beams are underpinned by girders and posts as the subsurface digging proceeds.

On Sept. 22 the excavation and timbering of the section were so far advanced that only 50 ft. of ground was left between the main south heading, which had reached the south line of 25th St., and the north heading, which had crossed the north line of 25th St. Advance work in the north heading had been shut down, and back of it most of the permanent subway steelwork (columns and roof beams) had been erected. In the south heading the steel erection had extended to a point between 23rd and 24th St., while from here north to the face of the bench the footings for the permanent steel were being prepared.

A blasting gang came on duty in the south heading shortly before 8 a.m., Sept. 22, to shoot the holes in the

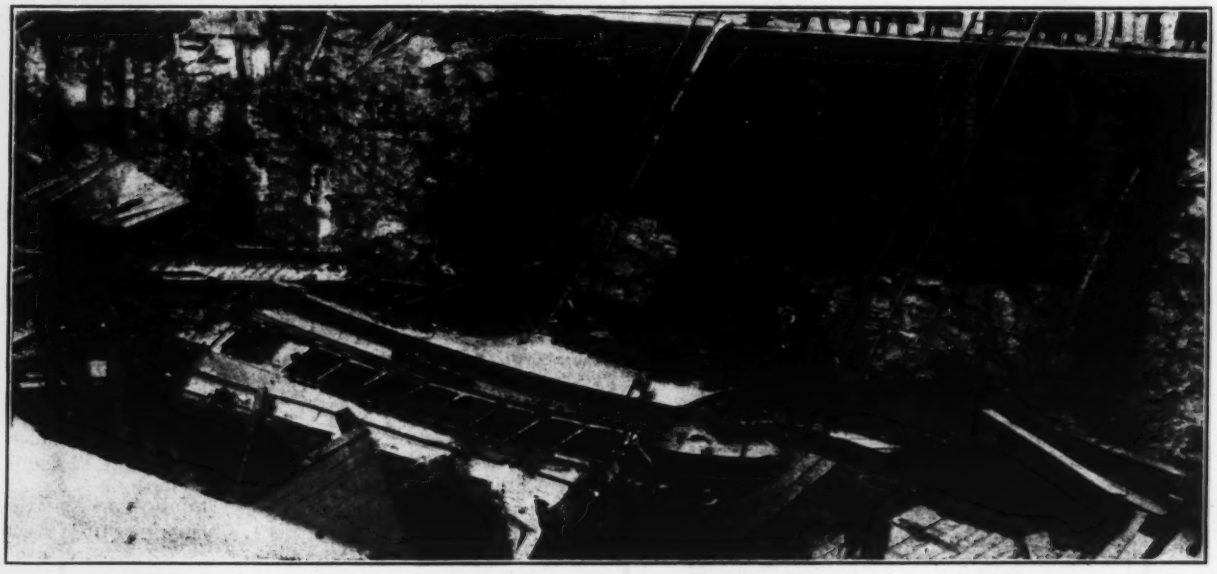
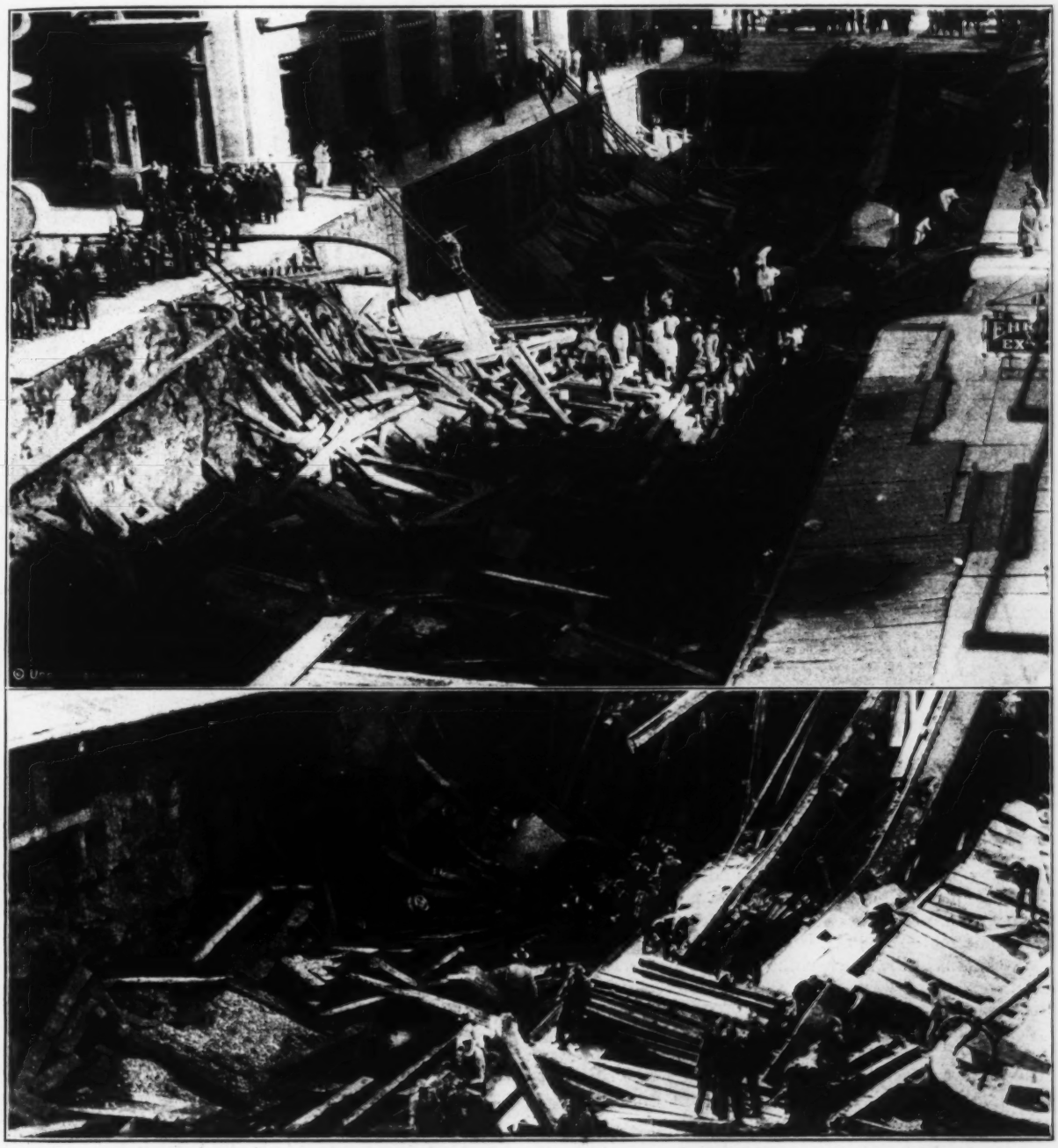


FIG. 2. LOOKING SOUTHWESTERLY INTO THE EXCAVATION AT THE COLLAPSE

east half of the bench—east and west halves being worked separately. One blast, possibly two, were shot, and then at once the whole street roadway came down, over the full width of the cut, and back more than a block, to the point where the permanent steelwork was in place (see sketch, Fig. 1). A loaded northbound street car, which was held by a flagman halfway between 24th and 25th St., fell to the bottom with the tracks, and two wagons also went down. Eight dead were later taken out of the car.

The wreck showed the roadway planking lying in fairly regular arrangement on top of the pile in the cut (see view, Figs. 3 and 4). It seems to have fallen straight down. The supporting timbers and I-beams were not so regular in position; such of them as could be identified as to original location indicated a movement south. The four or five northerly bents of permanent steel, at the south end of the collapse, were crowded together and leaning south.



FIGS. 3 AND 4. HOLE IN SEVENTH AVE., NEW YORK, AFTER COLLAPSE OF TIMBERING IN SUBWAY EXCAVATION

Upper view, looking north, shows point of initial failure at right. Lower view, looking at south end of collapse, where the street timbering was carried on permanent subway steelwork

The timber used in the United States Realty section is shown in Fig. 5. The beams under the street planking and car tracks are carried by one 12x16-in. longitudinal stringer on either side of a central aisle. Bents of 6 to 8 posts, spaced 10 ft. apart along the work, support the stringers and also directly the roadway beams. These posts in turn foot on transverse 24-in. 80-lb. I-beams, one 25-ft. length on either side, set 12 to 15 ft. above the floor of the excavation. Four 12x12-in. posts, two under each I-beam, carry the load of the entire bent.

For bracing, the I-beams are strutted longitudinally by 4x8-in. or 8x8-in. spreaders wedged between their webs. Two or three such spreaders are used on either side of the central aisle. Also, the upper tier of posts is set on 4x12-in. or 6x12-in. foot-planks dapped over the top flanges of the I-beams in alternate bays between bents. Longitudinal spacer planks under the roadway beams also act as struts.

Transversely, the two I-beams of each bent are spread and tied by a pair of 12-in. 20½-lb. channels spanning the middle aisle and bolted to the I-beam webs. There are other spreaders, and at many places transverse diagonal bracing in the upper tier of posts, as indicated in Fig. 5. The outer posts are blocked against the side walls of the cut.

There is no longitudinal diagonal bracing in either upper or lower tier of posts.

At the forward end or bench, the timbering is bridged over to the top of bench by four longitudinal flying girders or "runner beams," two on either side, which extend from a support on the bench backward over at least three bents, and rest on independent framed towers at their back ends. These runner beams are 30-in. 200-lb. wide-flange I-beams, 42 ft. long. They carry the forward two bents (nearest the bench, where posts cannot be set, or if set might be displaced by blasting) by hanger bolts holding up the 24-in. I's of the bents. As bench excavation proceeds, the runner beams are set forward in 10-ft. steps, and their rear towers are moved in 20-ft. steps.

Conditions at the bench of the south heading at 25th St. are these: The west bench system is undisturbed, the runner beam and its tower (only one beam was used in the west half of this point) being still in place holding up the street planking; just back of the runner-beam section, however, everything is down. In the east half, not only is all the timbering down, but both runner beams are down, leaning up against the bench with their forward ends nearly at its top; both towers also are down, but the inner one of the two is lying on the floor of the pit, overturned and crushed flat, not far out of place. Fig. 1 sketches the conditions roughly.

The difference between the east and west bench conditions proves that the east runner beams or their towers were displaced or wrecked in the very origin of the collapse. Had the collapse started behind them the posted timbering should have pulled clear and left the bench section standing as in the west half. The collapse of the timbering southward of the bench section was apparently a southward tipping or buckling of the post system, possibly started by a heavy blow delivered against the front end of the timbering near the level of the 24-in. I-beams.

As a precautionary measure since the collapse, longitudinal diagonals have been spiked or bolted to the lower posts at intervals in the remaining timbering of this contract section.

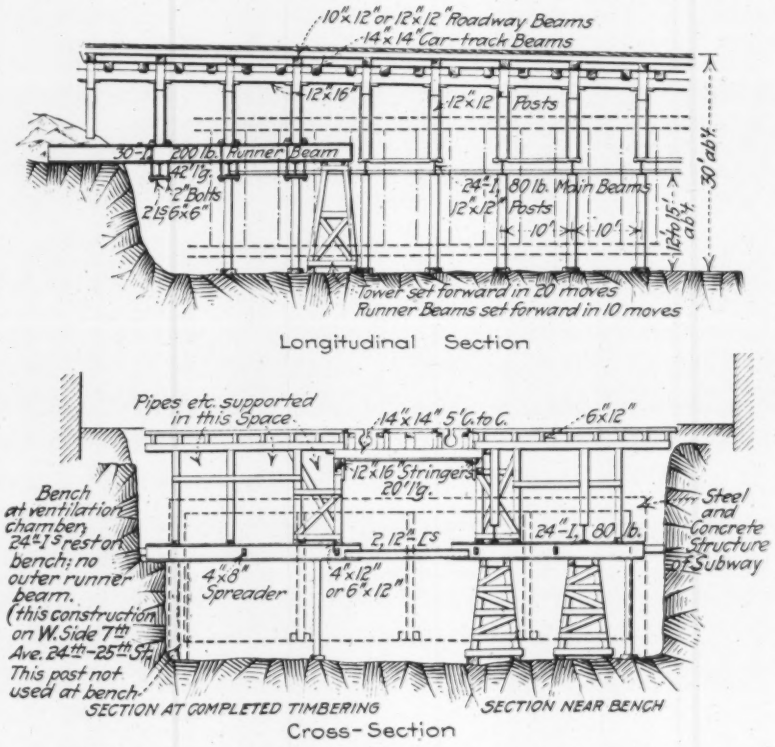


FIG. 5. ARRANGEMENT OF TIMBERING IN SEVENTH AVE.

The working system involves the use of transverse I-beams suspended from flying girders or runner beams near the face of the bench and carried on posts farther back

Investigations of the accident have been started by the coroner, the contractors, the Public Service Commission, the Mayor and other authorities.

Second Fall Due to Rock Slide in Broadway Excavation

Only three days after the Seventh Ave. accident described in the preceding article, a second collapse of subway timbering occurred in the work of the same contractor, but on another contract section. About 7 p.m., Saturday, Sept. 25, the timbering under Broadway near 38th St. was wrecked by a rock slide. Partly crushing and partly dislocating the system of posts and brace-struts, the slide dropped the roadway planking of half the street width for a length of 70 ft. into the pit. The planking of the east half, together with the two car tracks, remained hanging across the wrecked section by the suspension action of the track rails. One vehicle fell with the street planking, causing one death.

The point of collapse is directly in front of a theater, and four or five other theaters are within a radius of 300 ft. Had the collapse occurred half an hour later, therefore, the results would have been more serious.

The work at this point is part of the new Broadway-59th St. subway line to be operated by the New York Consolidated Railroad Co. (Brooklyn system). The section from near 32nd to 39th St. is being constructed by the United States Realty and Improvement Co. The structure is to be one-level four-track subway, with floor about 35 ft. below street. Rock is within 5 to 6 ft. of the surface; it is Manhattan schist, whose strata here stand nearly on edge. As indicated by the elevation of the bench face in Fig. 7, the dip is to the west. On the east side of the cut (right side in Fig. 7) the rock slopes so as to slide into the cut, and here some of the slabs have been doweled in place by steel rods grouted in holes. On the west side the blasting produces an irregular side face, with sheets of rock standing up partly undercut. Jointing planes slope down inward toward the cut.

FIG. 6. BROADWAY TIMBERING WRECKED BY ROCK SLIDE ON WEST SIDE OF CUT

The slide (Fig. 7) was a slip along such jointing planes of the rock of the west face. The appearance of the break shows this clearly (see Fig. 7 and view, Fig. 6). What disturbance started the slip could not be learned. According to the best evidence at hand up to now, no one suspected the seamy, dangerous nature of the rock at this point. The slip was about 12 ft. in thickness at its maximum, measured out from the original side of the cut.

The timbering of the Broadway excavation (Fig. 8) is closely similar to that used on the Seventh Ave. section of the same contractor (see Fig. 5, in preceding article). The main beams, however, are set above the permanent subway structure, and thus are located just beneath the piping under the street; the posts under them are strutted by two lines of longitudinal and transverse timbers. There are four posts in each bent, two under the 12x16 main stringers and two at the walls. Bents are spaced 10 ft. The outer posts, as observed in the standing work just south of the collapse, are blocked against the sides of the cut, both to hold the rock and to stiffen the timbering; this blocking varies from post to post. However, in the collapsed section the east face of the cut slopes inward on what appears to be a stratification surface, in a way to give little opportunity for effective lateral blocking.

The extent of the collapse is indicated in Fig. 7. Seven bents just south of the face of bench are totally destroyed. Three others are partly destroyed and partly distorted by having the tops of the posts pushed over eastward. South of this the timbering is in place and plumb, and there is no indication that the collapse transmitted any injurious action to it. Nevertheless, the posts in the undamaged portion were braced longitudinally by heavy tim-

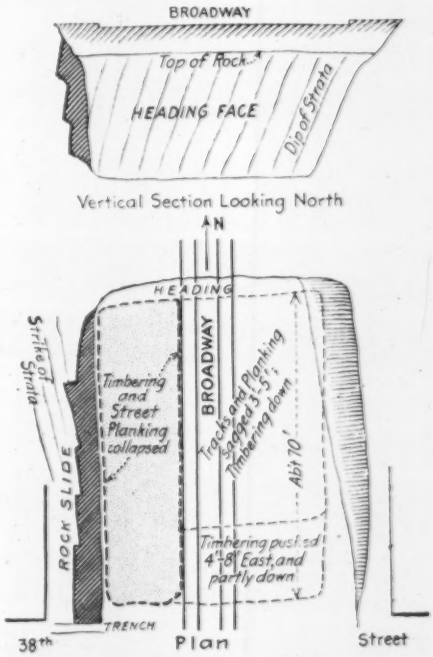


FIG. 7. SKETCHES SHOWING LOCATION OF ROCK SLIDE AND RESULTING COLLAPSE OF STREET SUPPORTS

ber diagonals immediately after the collapse, as extra assurance of security.

Where the collapse occurred the bench of the excavation had advanced to within 100 ft. of the north end of the United States Realty contract section. The adjoining section had not yet been attacked in the immediate neighborhood, so that there has been no opportunity to develop the rock structure just north of the region of the slide.

The police department stopped traffic on many of the most important thoroughfares of the city. Seventh Ave. was closed from 31st St. south. Broadway was closed from 26th St. to 39th St. to all except street cars, and from 33rd St. to 39th St. to all traffic. Crossings were closed along Broadway at 8th, 14th, 23rd, and at all crossings from 28th to 39th Sts. On Seventh Ave. the crossings of 14th, 23rd and 34th Sts. were closed, as were also the crossings of Sixth Ave. and 34th St., W. 10th and W. 4th Sts., and Christopher and Varick Sts.

This procedure stopped through traffic on the 8th, 14th, 22nd, 29th and 34th St. crosstown lines, as well as on

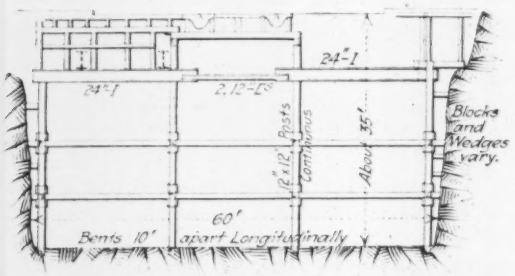


FIG. 8. TIMBERING SYSTEM USED ON BROADWAY

Arrangement similar to that used on Seventh Ave. (Fig. 5), but with main beams above subway structure and close to street surface; two sets of struts between posts

Broadway and on Sixth Ave. and Seventh Ave. This interference necessitated the operation of an improvised system of shuttle lines.

These rigorous measures were adopted by order of Police Commissioner Woods, following a resolution adopted by the Public Service Commission at its meeting on Sunday morning. The resolution was introduced by Commissioner Hayward, and recommended that all traffic on decked-over streets (except street cars) where the street supports were not of steel should be prohibited. Commissioner J. S. Cram offered an amendment to the effect that all heavy traffic be prohibited on Broadway.

This meeting was attended by all the members of the commission, its chief engineer Alfred Craven, Mayor J. P. Mitchell, and M. H. Smith, Chief Engineer of the Department of Water Supply, Gas and Electricity.

The city authorities from mayor down to Public Service Commission became enough aroused over the Broadway collapse that they appointed several experts and investigation boards.

The mayor's committee of engineers consists of the following members of the city's engineering forces: Nelson P. Lewis, chairman, E. P. Goodrich, J. W. F. Bennett, George W. Tillson, Eugene W. Stern, Merritt H. Smith, Amos L. Shaeffer, Edwin J. Fort, John R. Healy, Benjamin Welton, Francis Ferry, and R. W. Creuzbaur. For the Public Service Commission, investigations by its engineering staff will be supplemented by the services of Henry H. Quimby, Chief Engineer of the Philadelphia subways, Edmund S. Davis, Chief Engineer of the Boston subways, and J. H. Hammond, Jr.

The inquiries being conducted by the coroner and the district attorney are assisted by H. de B. Parsons as expert.

Danger of Collapse in Subways Is Not General

By Fred Lavis*

The two accidents on the new subways in New York City, occurring so close together both in time and location and resulting in the collapse of the roadway supported over the subway excavations, have, perhaps naturally, caused some apprehension in the minds of the responsible officials as to the general security of the comparatively large amount of street surface of this character now in existence. The writer made a very careful examination of all the work in progress a little over a year ago and was at that time impressed by the care exercised and the precautions being taken to avoid accidents of this kind.

It was recognized on all this work that owing to the greatly varied character of the so-called "New York rock" (the mica schist that underlies the whole city) it was impossible to predict with certainty what the results of every blast would be, and precautions were therefore taken to provide against complete collapse of the decking, even though one or even several supports were displaced either by rock thrown out by blasting or by slipping or sliding of the rock mass.

The extremely unstable character of the New York rock has always been realized, but even among the most competent of those who have had to handle it, it has not always been possible to entirely prevent trouble, as the series of disasters in 1902 in the Park Avenue tunnel of the original subway testifies.

In view of these conditions, therefore, it seems advisable to mention here briefly some of the general principles and methods adopted on the work referred to, which was described in some detail by the writer in a series of articles in *Engineering News* during the second half of 1914. This may tend to allay the fear that the conditions that have caused these last two accidents are general or that there is cause for general alarm over the situation.

Article VII of the series referred to describes the methods of timbering (*Engineering News*, Nov. 26, 1914, p. 1068), and the references herein to the figure numbers are to those of that article. At the outset it may be noted that, speaking generally, all the excavation below, say, 14th St. is in earth and above that point almost all in rock. Little danger from blasting or from sliding rock is to be expected, therefore, on the downtown sections.

At the time of the writer's examination of the construction work, and in conversations with both the engineers of the Public Service Commission and of the contractors, he was impressed by the evident realization on their part of the necessity of continuous support and the need of adequate bracing in all directions, as is shown by the following quotation from the article referred to, where it is noted that the design of the timbering in all cases not only provided for a clear working space, but was designed to

*Consulting Engineer, 50 Church St., New York City.

guard against disaster by the loosening or destruction of one or more supports by the blasting operations or by slides in the very unstable New York rock."

Taking up the references in order, it will be noted that in the fully timbered section of the usual ranger and cross-braced type (illustrated in Fig. 35 of the article cited) "tension rods were used throughout to hold up the bottom braces, and carefully placed *additional horizontal cross-bracing* was carried diagonally from the center at each of the shafts back through several bents to the sides." The vertical diagonals are shown in the photographs.

On Lexington Ave., "after some trouble with slipping and sliding rock, continuous girders were erected on the sidewalk line, spanning the section in which excavation was being carried on, and from which the street decking was hung as well as being supported from the bottom." (Figs. 36 and 41.)

Through the deep cutting for the 125th St. Station, a system of six pairs of 20-in. I-beams was used, three pairs under each track of the street railway. One pair under each track—that is four in all of these I-beams—was continuous throughout the length of the work, the joints being spliced to develop full strength; a second pair under each track—that is, another four beams—was 120 ft. long (with fully spliced joints) and they, as well as four more 80 ft. long, spanned the working space and were moved ahead as the work progressed, but they were all supported at more than one point. Unusual care was taken in all this work to splice all joints and to nail cleats at all connections. This made it somewhat more difficult to take the timber apart when it was necessary to remove it and of course damaged it more, but the structure was well framed and fastened together.

Figs. 37 and 42 show the vertical diagonals, or so-called "arch bracing" used on the section under Church St. and on Sec. 3—lower Broadway.

Fig. 40 shows a Lexington-Ave. section which was quite deep and where the rock was bad in many places. Here three pairs of I-beams spliced to develop full strength were placed immediately under the decking, one pair between the track and one pair on either side. There are three more pairs further down, and the whole structure is tied together. The vertical diagonals just below the deck form an arched support, the rakers at the side forming desirable supports, but arranged in such a way that the entire removal of even two or three at a time would not cause a collapse of the structure. Fig. 51 of the succeeding article (*Engineering News*, Dec. 3, 1914, p. 1108) shows a typical rock slide on Lexington Ave.

These references, it is believed, are sufficient to show that the difficulties and dangers of this work have been realized and at least on much of it fully provided for.

News of the Engineering World

Another Septic-Tank Decision

Another stage in the seemingly endless litigation over the Cameron septic patent in the United States has been reached by the denial of a plea entered by the defendant in one of the suits. (Cameron Septic Tank Co., complainant, vs. City of Winchester, defendant, United States District Court, Eastern District of Kentucky.) Some time time ago the company brought suit against the city, alleging that the two-story settling, or Imhoff, tank at Winchester, Ky., was an infringement of the Cameron, Commin & Martin United States Patent No. 634,423, of Oct. 3, 1899, process claims Nos. 1, 2, 3, 4, and 21. Proof on the main issue has not been submitted, the defendant pleading that the process claims just named expired in 1909 with the apparatus claims of the Cameron & Commin British patent (for 14 years) No. 21,142 of Nov. 8, 1895.

In a brief filed in May, 1915, the company denied the plea of the city and maintained that the process claims remain in force in the United States for the full 17-year term of the patent, or until Oct. 3, 1916. The United States District Court filed an order on Sept. 15, 1915, sustaining this plea. The order was not accompanied by an opinion. Unless the city appeals, the case will presumably go to trial on the main question of infringement, regarding which no evidence has yet been offered.

It may be added that in the Knoxville, Iowa, case (see *Engineering News*, Jan. 23, 1913, p. 189, and Feb. 6, 1913, p. 275) the United States Supreme Court ruled that Patent No. 634,423 expired in 1909 with the British patent already named, and that while the Cameron Septic Tank Co. maintains that ruling to be of no significance except in the Knoxville case, opposing attorneys have claimed the contrary. (For both contentions, see *Engineering News*, Feb. 6, 1913, as cited.)

Activated-Sludge Progress at Milwaukee, Wis.

Rapid progress with activated sludge as a means of sewage treatment is being made at Milwaukee, Wis. The status of both construction and experimental work is shown in the following statement prepared for *Engineering News* by T. Chalkley Hatton, Chief Engineer Milwaukee Sewerage Commission:

Three tanks of the 2,000,000-gal. unit will be in use by Oct. 1 in order to secure activated sludge for priming the entire unit, which will be completed by the middle of November.

The experimental continuous-flow tank which has been in operation since July (see *Engineering News*, July 15, 1915) has been giving splendid results. The volume of flow through the tank has been gradually increasing and the amount of air required for aeration decreasing, until now (Sept. 24) the sewage is being treated at a cost of about $4 per 1,000,000 gal., and that, too, with a resulting effluent that is stable, clear as tap water and that shows a bacterial reduction of between 95 and 99%.

We have gotten so far along with our experiments in the treatment of the liquor that we have no doubt in our minds of its success both from the sanitary and economical

standpoint, and we are now investigating very earnestly the disposition of the resultant sludge.

We have had this sludge analyzed by two fertilizing manufacturing companies, who have given us its available value based upon the nitrogen and fat content of about $12. We have been assured that there is an ample market for it as rapidly as it can be manufactured, and we are now engaged in making a study of the best apparatus for dewatering, degreasing and drying the sludge, and we think there will be no difficulty in securing proper apparatus for performing this work economically so as to leave a considerable margin of profit in the output.

Wind Wrecks Wireless Tower at Tufts College

By Frank B. Sanborn*

A high wind wrecked a 300-ft. wireless tower under erection by the American Radio and Research Corporation at Tufts College, Mass., on Sept. 26. The top section of the tower had just been put in place, but was not permanently secured when the workmen left the job on Saturday. During Sunday afternoon a 38-mi. wind, as recorded by the Weather Bureau, came up.

The tower, which was like a steel mast 300 ft. high, fell across a main street and the tracks of the Boston & Maine Railroad, Southern Division. (See views, Figs. 1 and 2.) It struck the track in front of an express train, derailing the locomotive but doing no serious damage.

The failure of the tower is attributed to defects in the guys. The top set of wire guys had not been completed; instead of the permanent set which was to be placed at the top, a temporary set of $\frac{5}{16}$-in. wire guys, and heavy manila rope as auxiliary, had been left in place. Furthermore, the guys had not been made-up tight and the tower was observed to sway excessively just before it fell. The guys broke on the windward side, and the tower fell with some evidence of twisting but no signs of buckling.

As shown by Fig. 2, the tower was composed of angle irons (3x3x$\frac{1}{4}$-in.) for posts and horizontal and diagonal braces (2x2x$\frac{3}{16}$-in.). The braces were spaced 4 ft. apart in the vertical and bolted at each end with a $\frac{7}{16}$-in. bolt. In cross-section the tower was 3½x3½ ft. Three sets of guys were to be used, one at 100 ft. above the base, one at 200 and one at 300 ft. Each set contained three ropes placed 120° apart. There were three concrete anchors about 150 ft. from the base. The lower guys were $\frac{5}{8}$-in. diameter, and the upper ones were to be ¾-in.

The tower was designed by J. R. Worcester, Boston, Mass., and the contract for erection was in the hands of the Builders Iron and Steel Co., Cambridge, Mass., but had been sublet by that company.

It is proposed to start erection again at once, making use of about one-third of the original members. A reinforced-concrete base (see Fig. 1) 5½x5½ ft. and 1 ft. thick, remained rigidly attached to the tower, and without cracking it supported the weight of the tower as thrust upon it during the fall.

*Professor of Civil Engineering, Tufts College, Mass.

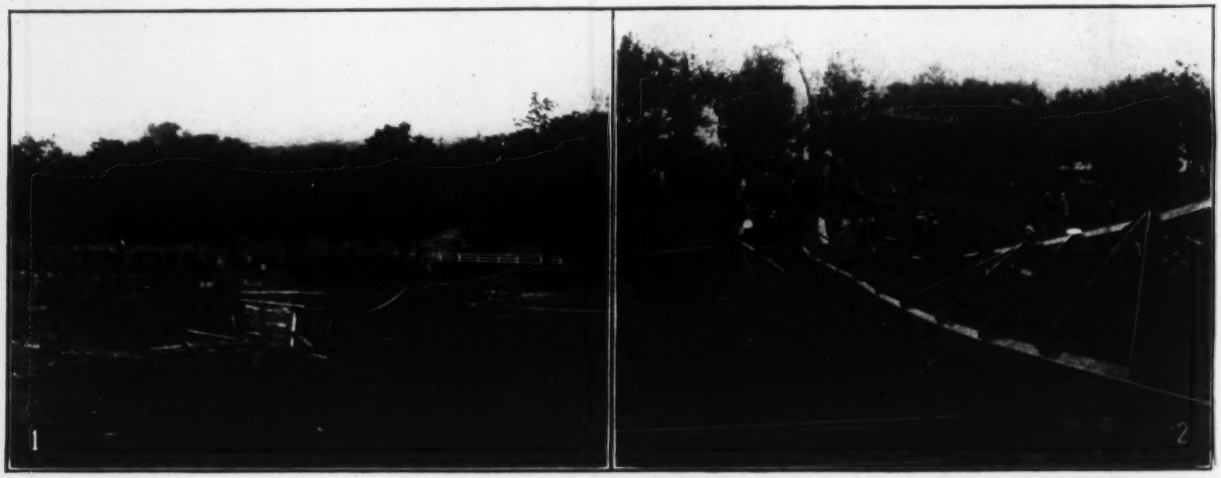
New Mississippi River Barges with Deck Gantries

A fresh start has been made in developing transportation on the Mississippi River and its tributaries. The Inland Navigation Co., recently organized under the presidency of John H. Bernhard, has begun the construction of 36 self-propelled shallow-draft steel barges. The first one of the fleet is now nearing completion at the Howard Ship Yards Co., Jeffersonville, Ind.

The barge, built under the regulations of the American Bureau of Shipping, is in all respects of steel construction. Transverse bulkheads divide it into five water-tight compartments. The propelling machinery consists of four three-cylinder oil engines of the four-cycle type, each operating one propeller.

The barges are 240 ft. long and 43 ft. wide over all, with mean draft (at 500 tons' load) of about 3½ ft. and full-capacity draft (at 1,600 tons' load) of about 7 ft. The deck is surmounted by a steel waterproof cargo box having removable sectional roof. Over this an electric traveling gantry is arranged to load and unload cargo, and by means of a 70-ft. extension boom to handle it to and from the bank.

There is the necessary auxiliary electric plant for lighting as well as for cooking, and for all power uses, including winches, steering, etc.



VIEWS OF WRECKED WIRELESS TOWER ACROSS RAILROAD TRACK AT TUFTS COLLEGE, MASSACHUSETTS

1. General view. 2. Detailed view at railroad crossing. From photographs by M. S. Munro

It is expected that these boats will prove so economical in operation that if sufficient advantage is taken of the new line by shippers an important increase in present transportation facilities will result.—John M. Sweeney, Monadnock Block, Chicago.

Water-Supply Improvements for Providence, R. I.

Extensive improvements to the water-supply of Providence, R. I., are to be carried out under direction of a water-supply board established at the last session of the Rhode Island legislature as the result of investigations that have been carried on during the past two years.

The present supply of the city is taken from the Pawtuxet River at Pettaconset, about five miles southwest of the city. While the upper reaches of the Pawtuxet River flow through a sparsely populated farming district, the lower portion of the valley is lined with manufacturing towns. The water is now pumped by electric centrifugal pumps onto sand filter beds, and the filtered water from these beds is pumped to a distributing reservoir, requiring a lift of about 180 ft. Additional pumping of this supply is necessary to reach elevated portions of the city. The new source of supply is demanded, not only because of the serious and increasing pollution of the Pawtuxet River at the point where the city takes its supply, but because at low water the river has a flow of only 12,000,000 gal. per day, while the average consumption of Providence is nearly 20,000,000 gal. per day, with a maximum consumption of over 25,000,000. The numerous milldams in the Pawtuxet above the city's intake also greatly interfere with the regularity of the river flow.

A joint special committee on increased water-supply, of which B. Thomas Potter was chairman, investigated a number of possible sources for future supply, with the assistance of Samuel M. Gray and Frederick P. Stearns as consulting engineers. As a result of these investigations, the north branch of the Pawtuxet River was selected as a future source of supply and the special committee was continued as a board to construct the works it recommended.

It is proposed to build a dam about 80 ft. in height and thus create a large storage reservoir. The drainage basin supplying this reservoir is sparsely populated, nearly all the mills in the river being located lower down on the stream at various falls. Water from this reservoir will be delivered by gravity to the distributing reservoirs in Providence, thus eliminating all but high-service pumping. The conduit to be built will be about 8 ft. in diameter, mostly in tunnel.

The legislative act enabling Providence to build the proposed new works contains an interesting requirement for the maintenance of the flow of the Pawtuxet River. During the period while the reservoir is filling, the city must allow 20,000,000 gal. per day to flow down the stream and may store only the water in excess of such a rate of flow. After the city has accumulated 20,000,000,000 gal. of water in its reservoir, it must draw from the reservoir in each month a quantity equivalent to at least 70,000,000 gal. daily, of which such portion as is required may be devoted to municipal use, the remainder to be discharged into the stream below the dam. Additional provisions are inserted requiring the city to forever discharge from its reservoirs sufficient water to maintain a certain rate of flow at specified milldams and manufactories farther down the stream. At one of these it is required that a quantity of not more than 72,000,000 gal. per week must be delivered as the owner of works shall certify from time to time is necessary for his use for manufacturing purposes other than the production of water power. The city may be required to pay damages to the employees of any manufacturing establishment that is condemned under the act by reason of their loss of employment.

The Providence Water-Supply Board has recently appointed Frank E. Winsor as chief engineer and Samuel M. Gray as consulting engineer. The engineering force for the work is now being selected.

C. & A. R.R. Adopts Automatic Mail Exchange

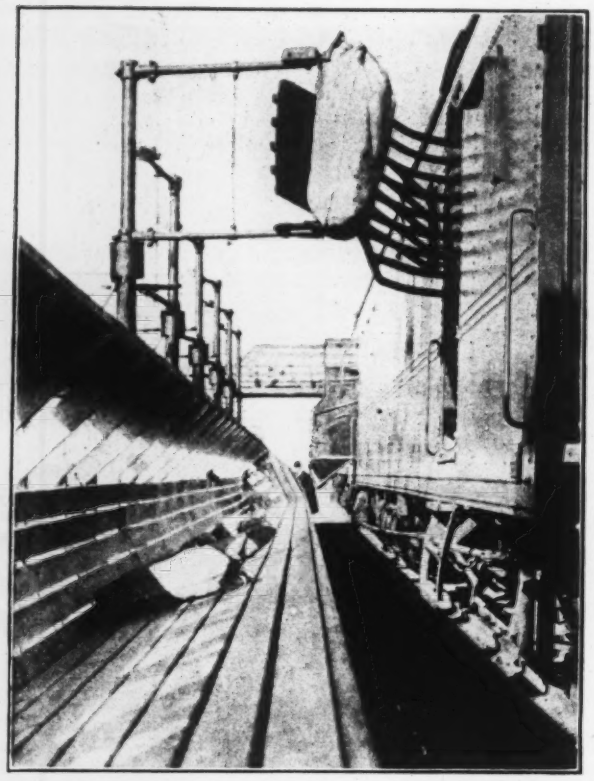
An automatic apparatus for the exchange of mail bags between stations and moving trains has been adopted by the Chicago & Alton R.R. for its line between Chicago and St. Louis. The distance is 284 miles and there are about 35 exchange points.

The station equipment consists of a platform on which are mounted the mail cranes, and beneath which is a trough with floor sloping away from the track. This trough is to receive the bags dropped from the cars, thus reducing the fall and protecting the contents from injury. The trough is about 100 ft. long and 5 ft. wide. The mail cranes are somewhat similar to those ordinarily used, but are set farther from the track and are so made that the arms swing aside when unlatched by the removal of the bag. The crane carries only one bag, but the number of cranes at any point depends upon the amount of mail to be handled, and the train will pick up practically any number of bags in succession.

The equipment on the car includes the mechanism for operating the door, catcher and delivery chute. This is driven by gearing from one of the car axles, but is in operation only while passing an exchange point. It is set in action by a track instrument, or trip, and the corresponding trip on the car is so housed that no obstruction except the track trip can engage it. As soon as the series of motions has been completed the mechanism goes out of action until started again at the next exchange point. The mechanism moves slowly, owing to the use of reducing gear, there being one revolution of the operating shaft to 115 revolutions of the car axle, so that there is no violent shock or slamming in the several movements.

The accompanying figure shows both the station and car equipment with the system in operation. In this view the train has taken five bags and the catcher is just engaging the sixth. At the rear will be seen the mail-delivery compartment projecting from the side of the car and with its bottom chute dropped to deliver the bags to the timber trough.

The track trip is set 456 ft. in advance of the exchange point and starts the mechanism, the operations being controlled by three slowly moving cams. The first cam unlocks and opens the sliding doors while the train travels 180 ft.; it holds them open during a travel of 480 ft. while the bags are taken and delivered, and it then closes and locks the doors during a travel of 180 ft. Thus the



C. & A. TRAIN TAKING AND DELIVERING MAIL

total distance from the time the doors begin to open until they are closed is 840 ft.

The distances given are for cars having 36-in. wheels, but for larger or smaller wheels the track trip is set at the proper distance. When the trip is engaged a gong is sounded in the car, announcing that the exchange is about to take place.

The second cam operates the catcher. This apparatus consists of a curved arm, or chute, to take the bags from the cranes, guide them through the door and drop them upon the floor. This arm, the curved part of which extends inside the car, lies normally against the outside of the car and is swung into catching position (after the doors have been opened) while the train is traveling 180 ft. They are held in this position for a similar distance and then closed, their complete operation being effected during a travel of 540 ft.

The delivery chute is an upright steel compartment, or locker, extending nearly the full height of the side of the car and its outer face forming a part of the side. Within this the mail bags are stacked. The third cam operates this simultaneously with the operation of the catcher. The chute is thrust outward on horizontal guides while the train moves 180 ft. The bottom then drops, forming an inclined apron to deliver the bags into the receiving, or station, trough, which is only a few inches below the level of this apron. The chute is withdrawn into the car and locked in its normal position during a second distance of 180 ft.

Delivering the bags in this way greatly reduces the liability of damage to mail matter (even with parcel-post packages), while it eliminates the present liability of injury to persons being struck by bags thrown out at stations and road crossings. It also eliminates the liability of dropping bags at wrong places, because of mistake or miscalculation of the mail clerk, and the further chance of a bag striking some obstruction and being thrown under its wheels, with consequent loss and damage to the contents or, possibly, derailment of the car.

This mail-exchange system is the invention of Albert Hupp. It is being introduced by the Hupp Automatic Mail Exchange Co., Washington, D. C., and Chicago, Ill.

A Gasoline-Vapor Explosion Killed 31 and injured 200, and caused property loss estimated at $500,000, in Ardmore, Okla., on Sept. 27. The explosion resulted from a spark from the hammer of a workman engaged in repairing a leak in a tank car. The car is reported to have contained 250 bbl. of gasoline. The spark undoubtedly ignited gasoline vapor in the tank above the liquid. The concussion wrecked two blocks of buildings, and the scattered blazing gasoline started numerous fires. The accident indicates a serious lack of adequate fire-prevention regulations.

The Permit for Building the Coatesville Dam for the improvement of the water-supply of Coatesville, Penn., will not be rescinded by the State Water-Supply Commission, notwithstanding the arguments for such action summarized in "Engineering News" of Sept. 2, page 477.

Experiments on Treating Lake Water with Copper Sulphate to prevent trouble from algae growths were conducted for the City of St. Paul, Minn., from June 12 to Sept. 12, 1915, as recommended by Allen Hazen, consulting engineer, New York City. The work was in the immediate charge of N. L. Huff, Professor of Botany, University of Minneapolis, who will make a report on the subject.

Work on Quebec Bridge continues to make good progress. Since the notes in "Engineering News," Sept. 2, 1915, the fifth main panel on the north cantilever arm has been completed. On the south shore the lower web members are all in and two panels of the upper web members and top chord. The high record noted on p. 473 of the issue of Sept. 2, as 1,240,000 lb. erected in one week should have read "in one day."

Extensive Improvements to the Water-Works of St. Paul, Minn., are soon to be started with the proceeds of a proposed $400,000 bond issue. Plans and specification for a 15,000,000-gal. pumping engine will be ready Nov. 1, so a 4,500,000-gal. pump may be replaced during the winter. By Feb. 1, 1916, plans and specifications will be ready for motor-driven revolving screens, 30,000,000- and 7,000,000-gal. covered reservoirs, and two venturi meters with necessary piping. These improvements are a part of those recommended some months ago by Allen Hazen, consulting engineer, New York City. G. O. House is general superintendent of the St. Paul works.

Plans for Rebuilding the Sewage-Pumping Station of Batavia, N. Y., which was wrecked on Sept. 18, are being made by Chester & Fleming, consulting engineers, Pittsburgh, Penn. The pump well and superstructure will be rebuilt as a structure completely isolated from the water-works and electric-light station, which the old sewage-pumping station adjoined. Electric-driven pumps will be substituted for the old rope-driven pumps, which were put out of commission by the explosion—perhaps only temporarily. The primary explosion may have been caused by striking a match to relight a gas jet between a wooden first, or main, floor and a reinforced-concrete floor below it, for the main floor was forced upward and part of the other floor downward. The forcing upward of a quadrant of the lower floor suggests a second explosion, set off through a stairway leading down to a third landing.

The Railway-Terminal and Grade-Crossing problem at St. Joseph, Mo., has been reported upon at the request of the Commerce Club by Hiram J. Slifer, consulting engineer, of Chicago. The nine railways (trunk and terminal lines) have 33 mi. of main track and 90 mi. of sidetrack, and own or occupy 720 acres of land. There are about 85 regular passenger trains and 60 regular freight trains daily. Within the city limits there are 112 grade crossings (some used by two or more railways), and several of these are in the business district and near the union station. As all the lines enter the city on descending grades, Mr. Slifer advocates track elevation. He proposed to replace the present lines in the heart of the city by a four-track embankment along the water front, with connections at either end to the existing lines and with a new union station at the foot of Francis St., where ample property is owned by the railways. It is proposed that a more detailed study of the project should be made by a commission representing the railways, the State Railway Commission, the city, and the Commerce Club.

PERSONALS

Mr. Alexander J. Taylor, Assoc. M. Am. Soc. C. E., City Engineer of Wilmington, Del., has resigned to join the engineering corps of the E. I. du Pont de Nemours Co. Mr. Taylor has been in the employ of the city for about 16 years.

Prof. G. L. Larson, formerly Professor of Mechanical Engineering at the University of Idaho, and for the last year Fellow in the Department of Steam and Gas Engineering of the University of Wisconsin, has become Associate Professor.

Mr. P. M. Fogg, Assoc. M. Am. Soc. C. E., formerly Project Engineer of the United States Reclamation Service at Lawton, Okla., has entered into partnership with Mr. E. E. Miller, Consulting Engineer, with offices at 1136 First National Bank Building, Denver, Colo.

Mr. Karl R. Kennison, Assoc. M. Am. Soc. C. E., until recently Principal Assistant Engineer to Mr. John R. Freeman, M. Am. Soc. C. E., Consulting Engineer, of Providence, R. I., has been engaged as Assistant Engineer on the staff of the Providence Water-Supply Board.

Capt. James J. Loving, Corps of Engineers, U. S. A., now on duty at Ravenswood, W. Va., in connection with the construction of the locks and dams in the Ohio River, has been transferred to Washington, D. C., where he will relieve Capt. W. D. A. Anderson as Assistant Engineer Commissioner of the District of Columbia.

Prof. Elwood Mead, M. Am. Soc. C. E., Professor of Rural Institutions at the University of California, has been appointed a member of the California Rural Credits Commission. Professor Mead recently returned to this country after a number of years of service as Chairman of the State Rivers and Water-Supply Commission, Victoria, Australia.

Capt. William D. A. Anderson, Corps of Engineers, U. S. A., has been transferred to Panama as Assistant to Colonel Harding on fortification work. He will succeed the late Capt. William F. Endress, who died of pneumonia en route to the United States from Panama. Captain Anderson for the past year has been Assistant Engineer Commissioner of the District of Columbia.

Mr. A. A. Bull, recently associated with the Northway Motor Manufacturing Co., of Detroit, has been appointed Assistant to Mr. Charles S. Crawford, Chief Engineer of the Cole Motor Car Co., of Indianapolis. Mr. Bull is well-known in Great Britain, where previously to coming to America he was connected with Humber, Ltd., and the English branch of the Daimler Co.

Prof. J. G. Callan, formerly associated with the General Electric Co. and later connected with the Arthur Ladder Co., has been appointed Head of the Department of Steam and Gas Engineering of the University of Wisconsin, to take the place of Prof. H. J. Thorkelson, M. Am. Soc. M. E., who has been made Business Manager of the University. Professor Callan was at one time consulting engineer for the City of Boston.

Messrs. A. H. Smith, Assoc. M. Am. Soc. C. E., and L. A. Boulay, who have been associated under the firm name of the Smith & Boulay Co., Consulting Engineers, 320 The Nasby, Toledo, Ohio, announce that beginning Oct. 1 Mr. Smith will conduct an office and business under the name of the A. H. Smith Co., Consulting Engineers, at the foregoing address, and Mr. Boulay under the name of the L. A. Boulay Co., Civil and Sanitary Engineers, 1248 Nicholas Building, Toledo.

Messrs. George H. Frost, Assoc. M. Am. Soc. C. E., formerly President, and Francis W. Frost, formerly Treasurer, of the Engineering News Publishing Co., are now President and Vice-President and Treasurer respectively of Frost & Cundill, Inc. This is only a change in the firm name of Suffern & Co., 64 Wall St., New York City, and does not in any way affect the policy of the company or the personnel of its management. The company does an export and import business.

Messrs. A. V. Kieslich and Oscar Heininger, of Burlington, Vt., and A. H. Heininger, of Boston, have formed an engineering and contracting firm known as the Kieslich Construction Co., with offices at Burlington. Mr. Kieslich for 10 years has been in engineering and contracting work about New England and retires from the firm of Elliott & Kieslich, of Burlington. Mr. Oscar Heininger has been connected with the Burlington Water-Works Department for over 30 years. Mr. A. H. Heininger for seven years has been with the sales department of the Boston Edison Illuminating Co.

Prof. Albert Victor Bleininger, who has been in charge of the Ceramic Section of the U. S. Bureau of Standards at Pittsburgh since 1912, has been appointed Professor and Head of the Department of Ceramic Engineering of the College of Engineering of the University of Illinois. After graduation from Ohio State University in 1901, Mr. Bleininger was in turn Instructor, Assistant Professor and Associate Professor of Ceramics in that institution, leaving there in 1907 to become Professor of Ceramics in the University of Illinois. The next year he was in charge of the Clay Products Laboratory of the U. S. Geological Survey, and two years later became Professor and Director of the Department of Ceramics at the University of Illinois, which appointment he resigned to become associated with the Bureau of Standards.

Mr. C. Stanley Sale, formerly Secretary and General Manager of the Engineering Publishing Co., of Indianapolis, and more recently Editor for the Chicago Association of Commerce Committee of Investigation on Smoke Abatement and Electrification of Railway Terminals, has been appointed Assistant to the Director of the Engineering Experiment Station and Instructor in Civil Engineering of the University of Illinois. Mr. Sale graduated from Purdue University in 1906 and was Assistant Engineer of the Florida East Coast Railway until 1907, at which time he became Associate Editor of the "Railway Age Gazette." Two years later he entered the employ of the Blount Plough Works, of Evansville, Ind., as Sales Manager, and the following year was made Business Manager of the Municipal Engineering Co., of Indianapolis, which connection he severed in 1912, when he joined the staff of the Engineering Publishing Co.

OBITUARY

John T. Johnson, General Superintendent of the Central Georgia Ry., died at Savannah, Ga., on Sept. 22.

Oscar G. Higgins, Chief Engineer of the Royal Baking Powder Co., died recently at his home in Brooklyn, N. Y., at 60 years of age. He was a native of Boston.

G. H. Williams, of Cleveland, Ohio, President and Treasurer of the G. H. Williams Co., of Erie, Penn., was killed on Sept. 25 in an automobile accident wheeh occurred at Harbarger Crossing, one mile west of Erie.

Fields C. Pendleton, of Brooklyn, N. Y., a member of the firm of Pendleton Bros., ship brokers, of New York City, and a master mariner and shipbuilder, died on Sept. 22 at Isleboor, Me., his birthplace.

Robert S. Greenleaf, an engineer formerly on the staff of the Oregon-Washington Railway and Navigation Co. and well-known in the State of Oregon, died at his home in Portland, Ore., on Sept. 2, at 67 years of age. He was born in St. Louis and served throughout the Civil War. In 1884 he went to Oregon and entered the service of the Oregon-Washington Co.

Maximilian Lewinson, M. Am. Soc. C. E., President of the contracting firm of Lewinson & Co., of New York City, died suddenly at his home in Scarsdale, N. Y., on Sept. 19. He was born in Poland and came to America 35 years ago. He began his career in this country as a civil engineer in the employ of Mr. Leopold Eidlitz, Sr., of New York City. He was in his 61st year.

Charles Edwin Williams, founder and senior member of the firm of Williams, McNaughton & Bapst, contractors, of Buffalo, N. Y., died at his home in that city on Sept. 22. Mr. Williams was born in Buffalo in 1852 and after leaving school he entered the office of his father, a general contractor. Later, he took an engineering course at the Polytechnic Institute of Stuttgart, Germany, and on returning to Buffalo entered the general contracting business, from which he retired in 1909. One of the most notable pieces of work which Mr. Williams executed was the government breakwater at Buffalo in 1885. He was also President of the German Rock Asphalt and Cement Co.; Vice-President of the Buffalo Dredging Co.; President of the Buffalo Northern Realty Co., and President of the North Collins Fuel and Gas Co.

Cornelius J. Field, formerly Chief Engineer and Superintendent of the Edison Electric Illuminating Co. of Brooklyn, N. Y., and widely known through his association with Thomas A. Edison in the development and adoption of the electric motor omnibus in this country, died at his home in Brooklyn from typhoid fever on Sept. 25. Mr. Field was the first Chief Engineer of the old Edison United Manufacturing Co. and superintended the construction of the first central station for the distribution of electrical energy in Brooklyn. He built

the electric street-railway systems in the cities of Buffalo, N. Y.; Newark, N. J.; Worcester, Mass.; Bridgeport, Conn.; Philadelphia, and other cities in the Eastern States, and did considerable construction work of the same kind in Europe. He constructed many miles of railway and several large sugar plants in the West Indies and at the time of his death was interested in engineering work for English sugar concerns in Cuba.

ENGINEERING SOCIETIES

COMING MEETINGS

NORTHWESTERN ROAD CONGRESS
Oct. 4-7. At Cedar Rapids, Iowa. Secy., Jas. P. Keenan, Milwaukee, Wis.

RAILWAY FIRE PROTECTION ASSOCIATION.
Oct. 5-7. Annual meeting at Chicago. Secy., C. B. Edwards, M. & O. R.R., Mobile, Ala.

NATIONAL PAVING BRICK MANUFACTURERS ASSOCIATION.
Oct. 11-12. Secy., Will P. Blair, Engineers Bldg., Cleveland, Ohio.

AMERICAN SOCIETY OF MUNICIPAL IMPROVEMENTS.
Oct. 12-14. Annual convention at Dayton, Ohio. Secy., Charles Carroll Brown, 702 Wulsin Bldg., Indianapolis, Ind.

AMERICAN RAILWAY BRIDGE AND BUILDING ASSOCIATION.
Oct. 19-21. Annual meeting, at Detroit, Mich. Secy., C. A. Lichty, 319 N. Waller Ave., Chicago.

SAN FRANCISCO MEETINGS

AMERICAN ELECTRIC RAILWAY ASSOCIATION.
Oct. 4-9. Secy., E. B. Burritt, 8 West 40th St., New York City.

AMERICAN ELECTRIC RAILWAY MANUFACTURERS' ASSOCIATION.
Oct. 4-9. Secy., H. G. McConnaughy, 165 Broadway, New York City.

American Society for Testing Materials—The letter ballot on the amendment of the by-laws, the revision of certain standards and the adoption of new standards, canvassed on Aug. 21, resulted in an affirmative vote on every item. The list of standards as revised includes 88 titles, as compared with last year's 70.

Engineers' Club of Kansas City, Mo.—Arrangements have been made with Maj. S. A. Cheney, Instructor in the School of Engineers, Fort Leavenworth, Kan., to give a course of lectures and lay out a reading course for interested members of the club who desire to take up the same during the coming winter. The subject will of course be military engineering, and the method of presentation will be designed to enable the men to qualify as officers in volunteer army organizations.

International Irrigation Congress—At the 22nd Congress, which was held at Stockton, Fresno, Sacramento and San Francisco, Sept. 13-20, the Engineering Section elected as Chairman for the ensuing year, F. C. Herrmann, Consulting Engineer for the Modesto Irrigation District, Merchant's Exchange Building, San Francisco. Richard F. Burges, El Paso, Tex., was elected President of the Congress; J. S. Dennis, Calgary, Alberta, First Vice-President; and Arthur Hooker, Fresno, Calif., was reëlected as Secretary. Resolutions were adopted in favor of rural credits and aid in land settlement; a national marketing commission; the completion of "meritorious" irrigation "projects outside of those begun by the Reclamation Service"; state control of irrigation districts and of private irrigation projects; revision of Reclamation-Service costs; Federal, state and provincial appropriations for stream gagings and for irrigation and drainage investigations; favorable consideration by Congress of the Newlands-Broussard bill for river regulation and control and the fullest possible use of the water resources of the West; and the appointment of a committee to report on permanent headquarters for the Irrigation Congress.

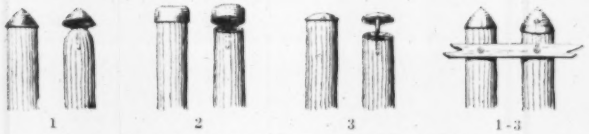
Appliances and Materials

Electrically Driven Fire Pumps

A line of centrifugal fire pumps with their shafts connected to an electric motor on the same bedplate is being introduced by the Hill-Tripp Pump Co., of Indianapolis, Ind., and has been approved by the Fire Underwriters' Associations, being equipped with the special fire-service fittings required by these associations. The discharge elbow, with manifold, hose valves, relief valves, etc., is supported on a pedestal adjacent to the bedplate. The pump is built in sizes of 500 to 1,500 gal. per min. capacity, with motors of 50 to 125 hp. respectively. The pressure is 100 lb. per sq.in. for all the pumps.

Permanent Iron Caps for Protecting Timber Piles

A variety of pile caps devised by Oscar A. Logan, 261 Broadway, New York City, are shown in the accompanying sketches. No. 1 is recommended for protecting old piles with rounded tops. Cap No. 2 is designed for new work. Cap No. 3



FOUR DESIGNS OF IRON PILE CAPS

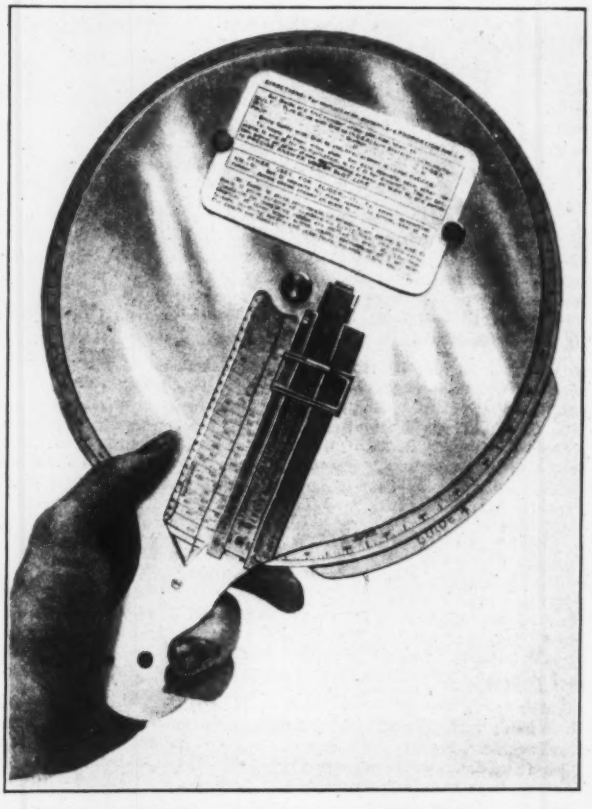
is recommended for placing on bunched piles. The caps are made of cast iron with wrought-iron spindles 1 in. in diameter and 8 in. long. No. 1 weighs 50 lb.; No. 2 weighs 60 lb., and No. 3, 17 lb. Pressed-steel caps can be furnished, but are not recommended. The fourth sketch shows a modified fastening.

* * *

New Graduated-Spiral Slide-Rule

A slide-rule that may be directly read to four places and estimated to a fifth has been put on the market under the name of the Ross Precision Computer. It is designed to be particularly useful for engineering computations, and is the invention of Louis Ross, of San Francisco, who invented and now manufactures the "Meridiograph," described in "Engineering News," Feb. 26, 1914. The new device is manufactured by the Computer Manufacturing Co., 268 Market St., San Francisco.

The logarithmetic graduations are along a 29-ft. spiral on a disk about 8 in. in diameter. The outside ring of



ROSS PRECISION COMPUTER—A SLIDE RULE WITH GRADUATION ON A SPIRAL

graduations is a scale of equal parts for addition and subtraction. The operations of multiplication and division are as simply performed as with any logarithmic scale. The auxiliary 4-in. slide-rule on top gives logarithmic numbers on the left-hand fixed scale and corresponding square and cube roots on the right-hand fixed scale. On the slide between are two logarithmic scales, both corresponding to the left-hand fixed scale but graduated in reverse directions. The computer is made of aluminum and german silver.

Engineering News

VOLUME 74 OCTOBER 7, 1915 NUMBER 15

Flooding and Recovery of the Astoria Tunnel--I

By Harold Carpenter*

SYNOPSIS—The great difficulties in holing through the headings of the Astoria tunnel, described in these pages two years ago, were surpassed by troubles arising in the bench excavation. The tunnel was drowned out, except for the Bronx end, which was saved by a narrow margin. Grout sealing on a huge scale finally controlled the leak.

Two years ago, at the very time when the writer's previous article describing the construction of the Astoria tunnel up to the point of holing through on July 17, 1913, was going to press[1], a tremendous flow of water burst into the tunnel, flooded three-quarters of its length and, filling the Astoria shaft, submerged the pumping plant. The following recounts the chief events in the successful struggle to recover and complete the tunnel.[2]

The tunnel is 4,662 ft. long. Its ends are in Fordham gneiss, for distances of 1,200 ft. north from the Astoria shaft and 750 ft. south from the Bronx shaft. Between these two points it passes through Inwood dolomite, and it was on the contact between these two rocks nearest the Bronx shaft, for a distance of about 400 ft., that seams of disintegrated rock carrying water under high pressure (95 lb. per sq.in.), were constantly encountered.

The width of this contact zone of decomposed rock was found to be about 150 ft. normal to the strike, but owing to the tunnel's crossing it at an angle, the greater distance was involved.

Because of the fact that the tunnel was 250 ft. below the surface of the river and therefore compressed air could not be used, the building of the tunnel through this water-bearing section presented unusual difficulties and required unusual methods to overcome them. Still

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[1]See "Engineering News" of Oct. 16, 1913, p. 737.

[2]The Astoria Tunnel connects the Astoria plant of the Consolidated Gas Co. of New York at Astoria (on the northwest corner of Long Island) with a future distributing station at East 132nd St. and East River, Bronx (see Fig. 2). It will be used to carry gas by means of 72-in. cast-iron mains from the Astoria plant, which will be the largest gas plant in the world, with its ultimate capacity of 240,000,000 cu.ft. of gas in 24 hr. (40,000,000 cu.ft. capacity is now constructed and in operation), to the growing northerly section of New York City, the Borough of Bronx, the population of which has increased from 88,000 in 1890 to 730,000 (estimated) in 1915. The reasons for its construction, its general details (see Figs. 2 and 3 of the present article) and the difficulties encountered and successsfully overcome up to the time of holing through the heading, were described in the previous article (see preceding note).

FIG. 1. THE ASTORIA TUNNEL, NEW YORK CITY, DEC. 1, 1913

This shows tunnel partly unwatered after flood of Oct. 5, 1913, caused by a leak of 12,000 gal. per min. in bench

greater difficulties presented themselves when the tunnel was flooded by the great leak of Oct. 5, 1913.

Holing Through Heading; Further Trouble With Leakage Was Not Expected

At the time of holing through the heading, July 17, 1913, all trouble from disintegrated rock seams and water in the heading had been overcome. Two safety bulkheads across the full section of the tunnel and three across the heading to protect completed portions of the tunnel against flood, as well as 29 temporary bulkheads across all or part of the heading to confine the water for grouting, had been constructed during the excavation of the heading through this 400-ft. section.

After holing through there remained 43 ft. of heading to be widened to full cross-section and 474 ft. of bench to be removed, which included all of the bench through the trouble zone. The two safety bulkheads across the full section of tunnel were still in position, one at each end, and two safety bulkheads were still in place across the heading on top of the bench.

All water-bearing seams encountered during the driving of the heading had been successfully grouted under high pressure (500 lb.), and the flow of water had been stopped. Direct connection of the seams with the surface of the river had been revealed during the grouting, but all evidence led to the belief that this had been shut off with the grout.

Test holes 16 ft. long had been systematically drilled along the bench at the points where the seams lay, from 1 ft. to 5 ft. apart, without striking any water, and as the water had always come in from above and never from the bottom, it was considered improbable that further trouble would be encountered.

Excavation of the heading to full cross-section was completed July 24, 1913, and the concrete lining of the arch above springing line July 25, 1913. The two safety bulkheads across the full section were too far from the faces of the bench to be of use (150 ft. and 200 ft. respectively); they were therefore removed, and as there appeared to be no further need to construct new ones close to the work, excavation of the bench was resumed Aug. 14, 1913. The bench had not been advanced at the Bronx end since July 23, 1912, and at the Astoria end since Nov. 14, 1912, on account of trouble in the heading.

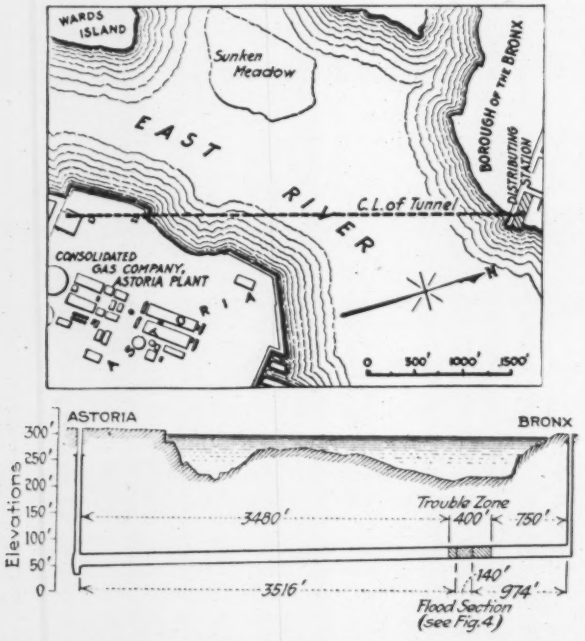

FIG. 2. PLAN AND PROFILE OF THE ASTORIA TUNNEL

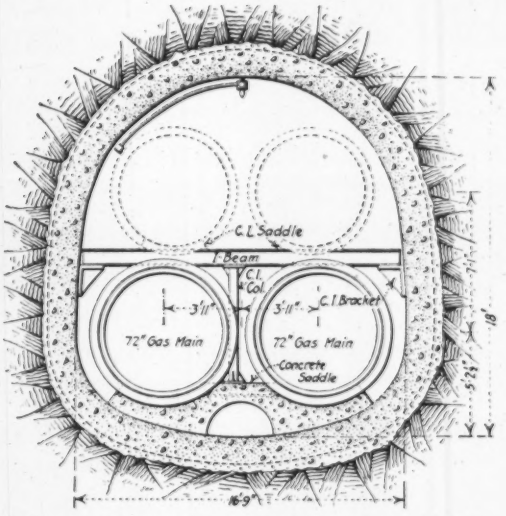

FIG. 3. CROSS-SECTION OF ASTORIA TUNNEL
Showing pair of 72-in. mains now being installed and future additional mains.

Water in Bench and Attempt at Grouting

For three weeks work progressed satisfactorily, 353 ft. of bench being removed. On Sept. 4 a test hole at the Astoria end of the bench, about 3,544 ft. from the shaft, drilled in an exactly similar manner and location to the previous exploring test holes, struck water under full pressure, giving a flow of 1,000 gal. per min. Several additional holes also struck water under pressure. The total flow from these holes was about 1,600 gal. per min. On the same day a test hole at the Bronx end, or 100 ft. north of the others, struck a 3-in. stream of water, but without pressure.

A temporary buttress 20 ft. long was built along the top of bench against the side of the heading and timbered against the opposite side of the heading to confine the water for grouting. The holes were piped through the buttress and valved as usual, being allowed to flow for one week, until the concrete had thoroughly set. The valves were then closed, preparatory to grouting, when instantly the water burst out through the top of the bench. The water pressure cracked the buttress in both directions.

Safety Bulkheads Built in a Hurry

Work was immediately started Sept. 11, 1913, on a safety bulkhead at each end of the bench, across the full section of tunnel, to protect the completed portions of the tunnel and shafts from flood.

In the meantime, on Sept. 12 a heavy flow of water occurred through the buttress drains and the top of the bench, bringing in large quantities of beach sand, shells, all sorts of débris, including wood, spools, tin cans, etc., and about a ton of coal in pieces as large as 4 and 5 in., showing that there was a direct connection with the river bottom. About 100 cu.yd. of material came in in less than an hour, when the holes clogged and the flow of refuse stopped, the water continuing.

Although such a direct connection existed with the river bed, no fish came in at any time during this flow or the subsequent flooding, while during previous water flows, when driving the heading, large quantities of live fish as long as 8 in. came in.

On Sept. 24 the two safety bulkheads across the full section of tunnel, one at each end of the 121-ft. section of remaining bench (*A* and *B* in Fig. 4), were finished, ready for use in an emergency. Several 8-in. and 10-in. drain pipes were built into each of these bulkheads below the doorways, with valves on the outside of the bulkheads. The doors were hinged on the inside and arranged to drop instantly on releasing a cable from the outside.

These bulkheads were completed just in time. Had it not been for them, the entire tunnel and both shafts would have been flooded on Oct. 5, 1913, under the circumstances described in what follows. As it was, only

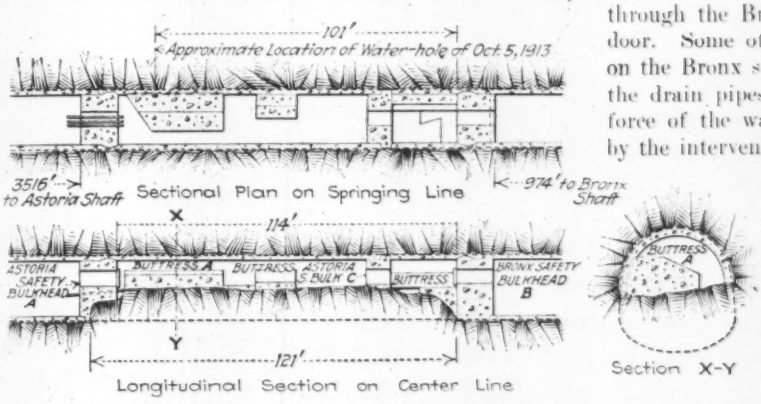

FIG. 4. CONDITIONS IN FLOOD SECTION AFTER FAILURE OF BUTTRESS, OCT. 1, 1913

Conditions at time of flood of Oct. 5 same except that buttress A had been removed

one shaft and one end of the tunnel were kept from being flooded; this undoubtedly prevented much more serious difficulties and much greater expense in recovering the tunnel.

Second Attempt to Grout the Leak

The buttress that had failed was now removed and a much larger one was built, about 35 ft. long, at the same location, well tied into the side of the heading and very heavily timbered against the opposite side of the tunnel. Other buttresses were also constructed along the bench wherever test holes had shown the presence of water or the rock seemed bad. (See Fig. 4.)

On Oct. 1 the buttress having had one week to set, the pipe valves were closed and grouting began. Immediately the 112-ton buttress (*A*, Fig. 4) cracked in both longitudinal and transverse directions and moved bodily away from the side of the heading a distance of ¾ in., crushing the timbers that were braced between it and the opposite side of the heading.

Its removal was at once started, in order to gain space in which to construct another in the form of an inverted arch. The buttress was removed as carefully as possible, blasting being done by means of very light charges, in order not to disturb the rock and start a flow.

On Sunday morning, Oct. 5, 1913, the removal of the large buttress (*A*, Fig. 4) was completed ready for concreting a new one, in the form of an inverted arch to replace it. At 7:40 a.m. the water coming in through the pipes and the top of the bench suddenly increased in volume and brought in a large quantity of green sand and débris. It ran thus for about half an hour, when it suddenly subsided again to its average flow of about 2,500 gal. per min. The sand was cleared away from the bulkhead doors, but it did not appear necessary to close them, as the flow had subsided.

Tunnel and Astoria Shaft Flooded

At 9:30 a.m. the heavy flow of water with sand and débris again broke out, in much greater volume than before. The men on duty, alarmed, at once prepared to close the bulkhead doors. Only with the greatest difficulty was the débris cleared away from the Astoria bulkhead A enough to allow the safety door to drop. This was finally accomplished, some of the men remaining on the outside to close the valves on the drain pipes. Others went out through the Bronx bulkhead *B* and dropped the Bronx door. Some of the men ran for the shafts. The men on the Bronx side were able to close all of the valves on the drain pipes through the Bronx bulkhead *B*, as the force of the water was broken and the sand held back by the intervening bulkhead *C* (see Fig. 4).

At the Astoria bulkhead, however, after the men had dropped the door, the rush of water and sand came so fast that they did not have time to close one of the drain pipes. This, remaining open, continued to discharge an 8-in. stream into the tunnel under 95 lb. pressure. It was afterward found that a 1-in. board had jammed in the doorway and water also poured into the tunnel underneath the door.

In about an hour and a half the pumps at the Astoria shaft, which had a rated capacity of 7,700 gal. per min., were all submerged. Some of the pumps continued to work until 4 p.m., when the last one stopped. The estimated flow of water from the leak was 12,000 gal. per min. At 8:15 p.m. the next day, Oct. 6, the water reached low-tide level and began to rise and fall with the tide.

From 9:15 a.m. to 6 p.m. bubbles appeared on the surface of the river directly over the point of leak for an area about 250 ft. square, one main body of bubbles extending over about 50 ft. by 100 ft. These bubbles appeared at a point about 400 ft. south of the point where similar bubbles had appeared on Apr. 8, 1913, during the grouting of a large leak in the heading with air pressure of 500 lb. (which had successfully shut off water from the heading). This showed that the new leak was from an entirely separate and new connection with the river bottom. Air also escaped from a small pipe through the Bronx bulkhead *B* at the same time.

The water in the shaft reached high-tide level for the shaft at 7 p.m. Oct. 7. Thereafter it rose and fell with the tide in the river, but lagged behind it in time between 2 and 3 hr. and in elevation by from 6 to 10 ft. Owing to an unusually high tide on Oct. 20, the water in the shaft reached its highest elevation of 4 in. below mean sea level, or 11.5 ft. below the top of shaft.

The Astoria shaft and 3,655 ft. of tunnel was now flooded with 10,000,000 gal. of water. A direct connection existed between the river and the heading, capable of discharging about 12,000 gal. per min. As the flow had

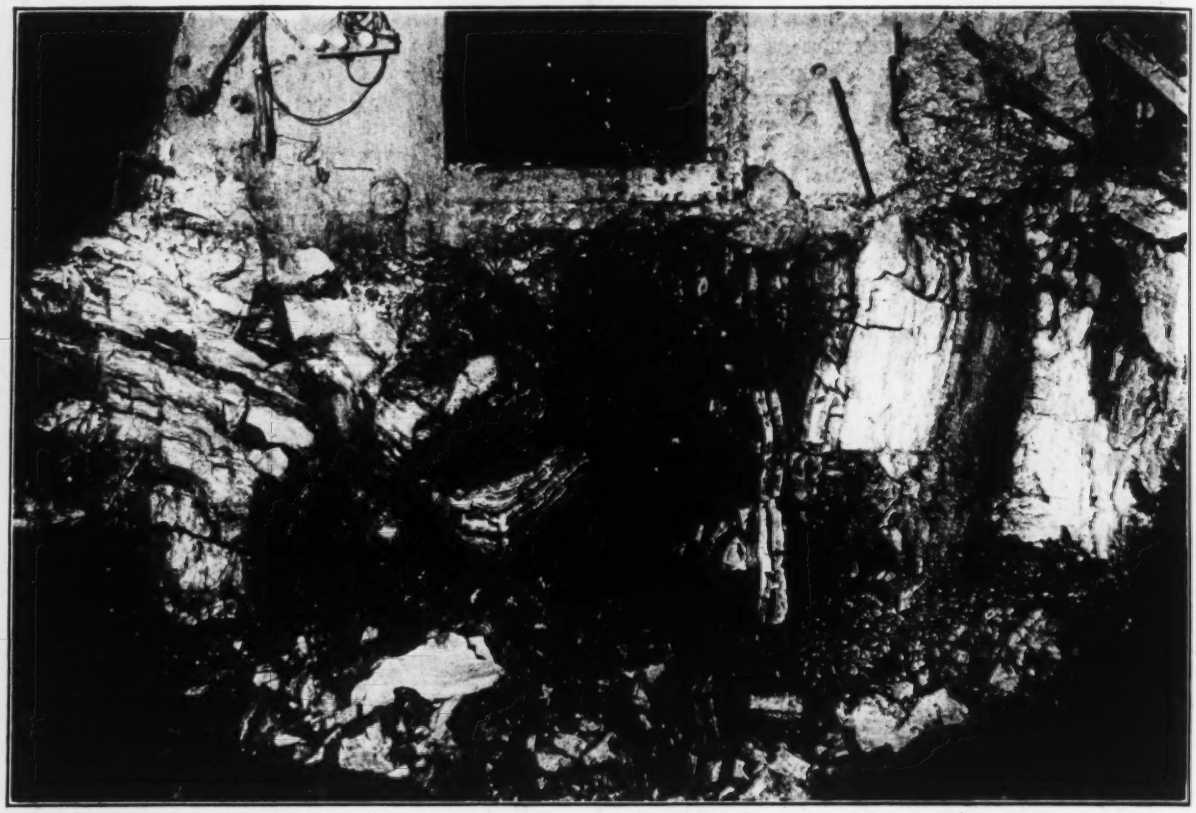

FIG. 5. FACE OF BENCH SHOWING SEAMS AND DISINTEGRATED ROCK, JAN. 30, 1914
Looking south from Bronx bulkhead to Bulkhead C

increased by five times in a few minutes, its liability to further increase had to be reckoned with. The entire pumping plant at Astoria was under 275 ft. of water. At the Bronx shaft a pumping capacity of only 1,200 gal. per min. was available.

FIG. 6. WATER FLOWING FROM TEST HOLES IN BENCH, JAN. 27, 1914
Test holes through temporary concrete invert just south of Bulkhead C

Only the Bronx shaft and the northerly 974 ft. of tunnel remained free from water, and this was protected only by a single bulkhead against which a water pressure of over 200 tons was acting. The nearest point of approach to the leak was the face of this bulkhead, about 114 ft. distant from the leak. While the Bronx bulkhead figured amply strong to withstand the pressure, the fact that the flooding of the entire tunnel, which would have presented a situation probably unprecedented and would have involved immensely more difficult and costly methods of unwatering, had been escaped by the narrowest margin, caused every possible additional precaution to be taken.

Work was at once started on a vertical abutment reinforced with rails and braced horizontally against the center of the Bronx bulkhead *B* (see Fig. 4) to strengthen it. Construction of a secondary safety bulkhead, reinforced with rails, 105 ft. north of the other, located in a section of the tunnel which had been previously lined with cast-iron rings, was begun as a further protection.

As the Astoria boilers could pump only 9,000 gal. per min. and the Bronx boilers 3,000, a total of 12,000, and the area in the Astoria shaft available for a float to mount pumps was

limited, it was impossible to unwater the tunnel until the flow from the leak was largely shut off. A steel pontoon, specially built, for mounting pumps in the Astoria shaft, and pumps of a capacity of 6,600 gal. per min. were purchased. The pumping plant at the Bronx was increased from 1,200 to 3,000 gal. per min., the capacity of the boilers.

During this time and during all of the operations that followed, close observations of the water level in the Astoria shaft were plotted, together with tide readings, and these gave quite a reliable indication of conditions in the flooded heading. At times the level of the water in the shaft closely approached, and several times even exceeded, the elevation of the river. These observations proved that there was still between the heading and the river a free connection, which must be shut off in some way.

Attempt to Grout Leak Through Core Borings

After discussing various methods, it was decided to first try drilling core borings through the Bronx bulkhead and the bench, in an attempt to reach the seam at a point outside the tunnel line and, by grouting the borings, shut off the water from the heading.

On Oct. 27, the bulkheads and additional pumps at the Bronx (to protect the Bronx shaft and end of the tunnel against flood) having been completed, work was started drilling the first 2-in. core boring, carefully aimed to reach the seam just outside the tunnel line and below the top of the bench. This hole was drilled a distance of 120 ft., struck water and green sand under full pressure, and was grouted with 870 bags of cement. Although it is believed that this hole entered the seam, it did not produce the desired result, as indicated by the action of the water in the Astoria shaft.

Filling the Entire Heading with Cement

It was now decided to fill the entire heading between bulkheads *A* and *B* with grout, in order to stop the flow of water from the leak in the tunnel sufficiently to allow the unwatering of the Astoria shaft and tunnel. In the meantime additional core borings were drilled with great difficulty, but very little grout could be forced into them, although water and sand with pressure was encountered, and they were not a success.

In order to grout into the heading a hole was drilled through bulkhead *B* and a 3-in. casing forced through this hole and up against bulkhead *C* (see Fig. 4). A diamond bit was then placed on the end of a 2-in. pipe and used as a drill rod to drill a hole through bulkhead *C*. When it was through, the 2-in. pipe was forced into the heading to a point opposite the leak. This work consumed 5 days. It was accomplished with great difficulties against the high pressure.

Grouting through this pipe directly into the heading to fill the entire heading with cement proceeded continuously from 3 p.m., Nov. 10, until 4 p.m., Nov. 12, with 100 lb. pressure; it consumed 8,600 bags of cement. This caused the water in the Astoria shaft to largely stop fluctuating and showed that the flow was largely shut off. Upon allowing water to flow from several small pipes in the Bronx bulkhead *B* to further determine conditions, the water in the Astoria shaft lowered 17 ft.

The consequent loss of pressure in the shaft and corresponding increase of pressure from the river on the

FIG. 7. EXCAVATION THROUGH GROUT; ASTORIA TUNNEL, NEW YORK CITY

Jan. 10, 1914. Drift excavated through grout between safety bulkheads placed to stop flow of water from flood of Oct. 5, 1913. Pipe at right is core drill rod through which the heading was filled with grout; drill head and 28 ft. of pipe removed. Timber at top is part of a strut to buttress A

grout caused it to give way, and the water in the shaft resumed its rise and fall. Grouting through the pipe (which had been kept free) was therefore resumed on Nov. 14 and 15. When some 1,700 bags had been forced in, the pressure gage on the Bronx bulkhead *B* exceeded the river pressure and grout appeared through the bulkhead pipes, so grouting was temporarily discontinued. On Nov. 17 grouting was completed, with a total of 11,542 bags of cement.

This grouting caused the water in the Astoria shaft to stop fluctuating except for a few inches, and on opening pipes through the Bronx bulkhead, they gave water but no pressure. Both phenomena showed that the flow into the tunnel had been shut off. Preparations were therefore made to begin pumping out the Astoria shaft and tunnel.

(*Concluded in next week's issue*)

Intensity of Rainfall Studied at Columbus, Ohio

By Charles Herrick*

The attempt to arrive at a more reliable method of obtaining the correct size of storm sewers has made it desirable to have accurate records of the intensity of rainfall for different periods of time. Such records have not been obtained in many places for a sufficient time to be of much service, so all records of this kind should be made available. The United States Weather Bureau Station at Columbus, Ohio, has had a recording rain gage in operation for the past 18 years, but the records have never been tabulated before.

The early rainfall records at Columbus are not very satisfactory, but there are three storms that should be mentioned in any discussion of the subject. The first occurred in 1867, but there are no records of its intensity. The second was on July 30, 1886. The rain started at 2 p.m., continued furiously till 2:40 p.m., then slackened, and stopped at 3:20 p.m. In 1 hr. 20 min., 2.83 in. of rain fell, which gives a rate of 2.12 in. per hr. The third unusual storm occurred July 24, 1896, when it is estimated that 2 in. of rain fell between 12 and 1 a.m.

The recording rain gage has been in operation at Columbus since Apr. 21, 1897. Between that time and the end of 1914 there were 65 storms with an intensity of precipitation of over 1 in. per hr.[1]

*1447 Highland St., Columbus, Ohio.

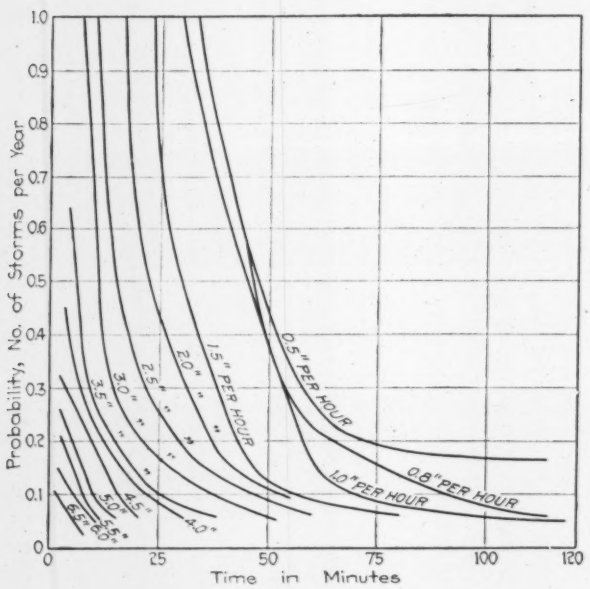

FIG. 1. PROBABILITY AND TIME FOR STORMS OF VARYING INTENSITY AT COLUMBUS, OHIO

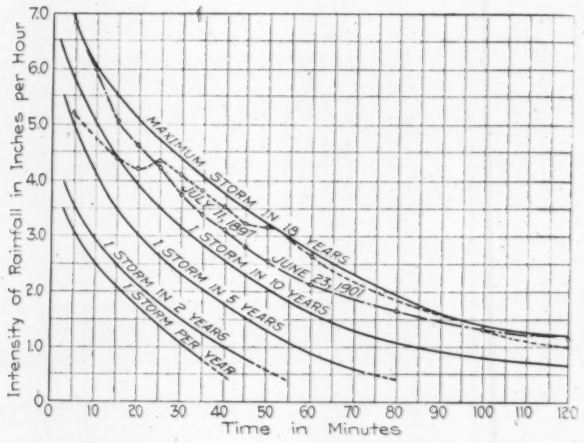
Intensity of Rainfall in Inches per Hour
Time in Minutes
MAXIMUM STORM IN 18 YEARS
JULY 11, 1897
JUNE 23, 1901
1 STORM IN 10 YEARS
1 STORM IN 5 YEARS
1 STORM IN 2 YEARS
1 STORM PER YEAR

FIG. 2. RELATION BETWEEN TIME AND INTENSITY OF RAINFALL FOR STORMS OF DIFFERENT PROBABILITY OF OCCURRENCE AT COLUMBUS, OHIO

In the monthly summary of observations special mention is made of all storms with an intensity of over 1 in. per hr. and with a total of over 2 in. per day. For the storms with an intensity of over 1 in. per hr. the following information is given: Date of storm; amount of precipitation before excessive began; accumulated depths of excessive precipitation in 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 60, 80, 100 and 120 min.; and the maximum precipitation in 5, 10, 15 and 30 min. Most of the data used in these studies were taken from these records, and from the sheets from the automatic gage for some of the heaviest storms.

The accompanying table shows accumulated and maximum rates of rainfall at Columbus for all periods of excessive precipitation from 1897 to 1914, inclusive. From this table the number of storms of an intensity of 0.5 in. or greater per hour, in 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 60, 80, 100 and 120 min. were determined. The same thing was done for intensities of 0.8, 1, 1.5, 2, 2.5, 3, 3.5, 4, 4.5, 5, 5.5, 6, and 6.5 in. per hr. These results were divided by 18, the number of years over which the records extend, and the probability, or number of storms of different intensity per year, obtained. These results were then plotted (Fig. 1) and from these curves were derived those given in Fig. 2. The points where the curves cross the horizontal line 1 give the number of

[1]When this gage was put in operation the station was in the Eberly Building, 215 South High St., 80.7 ft. above ground level. Since May 31, 1902, the station has been on the 12th floor of the New Hayden Building, 16 E. Broad St., where the gage is 170.6 ft. above the ground. The gage was moved from the south to the north end of the New Hayden Building on Sept. 26, 1906. The exposure had been slightly affected by a building 34 ft. higher on the west for a few weeks previous to this date. The rain gage is of the Friez tipping bucket type, with electric recording apparatus. (See Metcalf and Eddy's "American Sewerage Practice," Vol. 1, pp. 211-212.) The record-sheet cylinder is 15.07 in. in circumference and revolves four times in 24 hr., so that 0.21 in. represents 5 min. The water in the reservoir of the gage is measured at the end of the storm, and the excess is added to the amounts shown on the record, the most of this addition being made in the periods showing the heaviest rainfall.

minutes that these intensities might be expected to last in a storm that will probably occur once a year. The points where the curves cross the horizontal line 0.5 give the same information for storms occurring once in two years; the 0.2 line gives storms occurring once in 5 years, and the 0.1 line gives storms occurring once in 10 years.[2]

On examining similar records from other cities, it is evident that local conditions have a great effect on the intensity of rainfall. It is natural to expect greater rates of precipitation in Boston and smaller rates in Denver or San Francisco, than would occur in Columbus; but it is surprising to find as much difference as there appears to be in the rates of precipitation in such cities as Louisville, Cincinnati, Chicago and Columbus. In Cincinnati, the formula

$$i = \frac{16}{\sqrt{T}}$$

is used for the intensity of rainfall. For storms of from 10 to 85 min. duration this gives a smaller intensity than the maximum at Columbus, and for storms of 35 min. duration, is 1.3 in. per hr. less. For storms of over 90 min. duration the Cincinnati curve gives greater intensities than we have ever had in Columbus. It seems probable that a simple equation will not apply to such a range in the duration of storms and that a curve drawn through observed points is better than any mathematical expression.

[2]This method was used in Boston in 1904, and is described in Metcalf and Eddy, "American Sewerage Practice," Vol. I, pp. 231-234, and Fig. 98 and 99, p. 229.

It seems that storms approaching the maximum curve of Fig. 2 have occurred at intervals of from 7 to 9 years (1867, 1886, 1896, 1897 and 1901), but that no storm of this character has occurred since 1901. The curves for 5 and 10 years probably show too low an intensity on this account.

A very unusual rainfall occurred at Cambridge, Guernsey County, Ohio, on July 16, 1914, when 7.09 in. of rain fell in 1 hr. 30 min., or at the rate of 4.72 in. per hr. This excessive rainfall was confined to a nearly circular area not more than 8 or 10 sq.mi. in extent. While we may never have such a storm in Columbus, it is probable that we will at some time have a storm of greater intensity than any of which we now have records.

The studies summarized were made for the Division of Sewer Construction, Columbus, Ohio, and were based on the records of the Columbus station of the United States Weather Bureau.

The Production of Stone in the United States in 1914 amounted in value to $77,412,292, according to G. F. Loughlin, of the United States Geological Survey. This total was divided among the various classes of stone as follows: Granite, $20,000,000; trap-rock, $7,800,000; marble, $8,000,000; common limestone, $33,900,000; sandstone, $7,500,000. The value of the building stone produced in 1914 amounted to $17,796,000. Marble showed a slight increase. The value of paving stone produced was $3,772,000, while curbstone was valued at $1,870,000. Values of other classes of stone were as follows: Flagstone, $541,000; stone for rubble, $1,256,000; stone for riprap, $3,707,000; crushed stone, $30,162,000. There was a general decrease in the value of production since 1913. Pennsylvania is the greatest stone-producing state, Vermont being second, with New York, Ohio, California, Indiana, Massachusetts, Illinois, Wisconsin, Missouri, Georgia and Virgina following in order.

ACCUMULATED DEPTHS AND MAXIMUM RATES OF EXCESSIVE RAINFALL AT COLUMBUS, OHIO, 1897 TO 1914

Date	Note	Accumulated Depths of Excessive Precipitation, In. in Min														Maximum Rates of Rainfall for Different Periods, In. per Hr										
		5	10	15	20	25	30	35	40	45	50	60	80	100	120	5	10	15	20	25	30	35	40	45	50	60	80	100	120
July 11, '97*	0	0.20	0.28	0.40	0.65	1.05	1.35	1.65	2.00	2.45	2.62*					5.40	4.80	4.40	4.20	4.32	4.10	3.81	3.51	3.23	3.14	2.68			
July 21, '98	....	0.25	0.47	0.66	0.80	0.87	0.92	0.93	0.94	0.97	1.03	1.08	1.08	1.17	1.38	3.00	2.82	2.64	2.40	2.09	1.84	1.59	1.41	1.29	1.24	1.08	0.81	0.70	0.69
Aug. 3, '98	....	0.25	0.61	0.85	0.99	1.04	1.23	1.50	1.53	1.55	....	....	....	....	....	4.32	3.66	3.40	2.98	2.50	2.46	2.57	2.30	2.07	....	....	....	....	....
July 19, '00	Tr.	0.10	0.31	0.66	0.75	0.85	1.08	1.20	1.27	....	....	....	....	....	....	3.60	2.70	2.28	2.04	2.09	2.02	1.87	1.54	....	....	....	....	....	....
Aug. 16-17, '00	0.01	0.09	0.37	0.44	0.45	0.51	0.64	0.78	0.98	1.08	1.11	....	....	....	....	3.36	2.22	1.76	1.34	1.23	1.28	1.34	1.47	1.44	1.33	....	....	....	....
June 23, '01†	.....	0.27	0.84	1.27	1.54	1.75	1.86	1.92	1.98	....	....	....	....	....	....	6.84	6.00	5.08	4.62	4.22	3.76	3.40	3.10	2.80	2.59	2.16	1.67	1.33	1.13
Mar 7, '03	.....	0.07	0.13	0.17	0.27	0.40	0.51	0.52	0.53	0.53	0.54	0.57	1.09	1.13	1.14	1.56	1.46	1.56	1.56	1.30	1.10	0.96	0.89	0.79	0.71	0.59	0.82	0.68	0.57
June 20, '03	.....	0.13	0.20	0.24	0.41	0.51	0.57	0.58	....	....	....	....	....	....	....	2.04	1.62	1.32	1.23	1.22	1.14	1.00	....	....	....	....	....	....	....
May 14, '05	.....	0.27	0.32	0.38	0.43	....	....	....	....	....	....	....	....	....	....	3.24	1.92	1.52	1.29	....	....	....	....	....	....	....	....	....	....
Aug. 5, '05	.....	0.09	0.16	0.23	0.31	0.42	0.70	0.75	0.89	....	....	....	....	....	....	3.36	2.34	1.88	1.74	1.58	1.46	1.37	1.34	....	....	....	....	....	....
Aug. 5, '05	.....	0.18	0.27	0.36	0.44	....	....	....	....	....	....	....	....	....	....	2.16	1.62	1.44	1.32	....	....	....	....	....	....	....	....	....	....
Aug. 14, '05	.....	0.15	0.43	0.68	....	....	....	....	....	....	....	....	....	....	....	3.36	3.18	2.72	....	....	....	....	....	....	....	....	....	....	....
Aug. 19, '05	.....	0.17	0.24	0.44	0.52	0.56	....	....	....	....	....	....	....	....	....	2.40	1.44	1.76	1.56	1.34	....	....	....	....	....	....	....	....	....
Oct. 18, '05	.....	0.12	0.25	0.38	....	....	....	....	....	....	....	....	....	....	....	1.56	1.56	1.52	....	....	....	....	....	....	....	....	....	....	....
May 2, '06	.....	0.24	0.34	....	....	....	....	....	....	....	....	....	....	....	....	2.88	2.04	....	....	....	....	....	....	....	....	....	....	....	....
May 22, '06	.....	0.18	0.31	0.39	....	....	....	....	....	....	....	....	....	....	....	2.16	1.86	1.56	....	....	....	....	....	....	....	....	....	....	....
July 3, '06	.....	0.20	0.37	0.46	0.52	....	....	....	....	....	....	....	....	....	....	2.40	2.22	1.84	1.56	....	....	....	....	....	....	....	....	....	....
July 8, '06	.....	0.20	0.55	....	....	....	....	....	....	....	....	....	....	....	....	4.20	3.30	....	....	....	....	....	....	....	....	....	....	....	....
July 22, '06	.....	0.07	0.18	0.38	0.59	0.64	....	....	....	....	....	....	....	....	....	2.52	2.46	2.08	1.77	1.54	....	....	....	....	....	....	....	....	....
July 29, '06	.....	0.17	0.30	....	....	....	....	....	....	....	....	....	....	....	....	2.04	1.80	....	....	....	....	....	....	....	....	....	....	....	....
Aug. 3, '06	.....	0.05	0.26	0.49	0.58	0.71	0.79	0.81	0.81	0.87	0.92	....	....	....	....	2.76	2.64	2.12	1.98	1.78	1.58	1.39	1.22	1.16	1.10	....	....	....	....
Aug. 17, '06	.....	0.19	0.43	0.44	0.44	0.52	0.66	0.67	0.73	0.86	0.97	....	....	....	....	2.88	2.58	1.76	1.32	1.25	1.32	1.15	1.10	1.14	1.16	....	....	....	....
Aug. 19, '06	.....	0.19	0.38	0.47	....	....	....	....	....	....	....	....	....	....	....	2.28	2.28	1.88	....	....	....	....	....	....	....	....	....	....	....
Apr. 7, '07	.....	0.13	0.35	....	....	....	....	....	....	....	....	....	....	....	....	2.64	2.10	....	....	....	....	....	....	....	....	....	....	....	....
May 25, '07	.....	0.06	0.25	0.36	0.48	....	....	....	....	....	....	....	....	....	....	2.28	1.80	1.68	1.44	....	....	....	....	....	....	....	....	....	....
July 9, '07	.....	0.11	0.18	0.18	0.22	0.32	0.37	0.54	0.70	0.78	....	....	....	....	....	2.05	1.98	1.64	1.44	1.35	1.20	1.03	1.01	1.04	....	....	....	....	....
July 11, '07	.....	0.18	0.32	0.49	0.57	....	....	....	....	....	....	....	....	....	....	2.16	1.92	1.96	1.65	....	....	....	....	....	....	....	....	....	....
July 25, '07	.....	0.28	0.41	....	....	....	....	....	....	....	....	....	....	....	....	3.36	2.43	....	....	....	....	....	....	....	....	....	....	....	....
Aug. 20, '07	.....	0.16	0.49	0.72	0.82	....	....	....	....	....	....	....	....	....	....	3.96	3.36	2.88	2.46	....	....	....	....	....	....	....	....	....	....
Sept. 28, '07	.....	0.25	0.36	....	....	....	....	....	....	....	....	....	....	....	....	3.00	2.16	....	....	....	....	....	....	....	....	....	....	....	....
Mar. 18, '08	.....	0.25	0.41	....	....	....	....	....	....	....	....	....	....	....	....	3.00	2.46	....	....	....	....	....	....	....	....	....	....	....	....
June 22, '08	.....	0.07	0.15	0.27	0.40	0.46	0.53	....	....	....	....	....	....	....	....	1.56	1.50	1.32	1.20	1.11	1.06	....	....	....	....	....	....	....	....
July 24, '08	.....	0.19	0.53	1.00	1.17	1.30	1.35	....	....	....	....	....	....	....	....	5.64	4.85	4.00	3.51	3.12	2.70	....	....	....	....	....	....	....	....
Aug. 17, '08	.....	0.16	0.23	0.23	0.24	0.29	0.47	0.57	0.70	0.85	0.89	0.98	....	....	....	2.16	1.68	1.64	1.68	1.46	1.30	1.20	1.11	1.13	1.07	0.98	....	....	....
Apr. 25, '09	.....	0.20	0.32	....	....	....	....	....	....	....	....	....	....	....	....	2.40	1.92	....	....	....	....	....	....	....	....	....	....	....	....
June 8, '09	.....	0.12	0.29	0.43	0.51	....	....	....	....	....	....	....	....	....	....	2.04	1.86	1.72	1.53	....	....	....	....	....	....	....	....	....	....
July 12, '09	.....	0.15	0.34	0.54	0.65	....	....	....	....	....	....	....	....	....	....	2.76	2.34	2.16	1.95	....	....	....	....	....	....	....	....	....	....
Aug. 15, '09	.....	0.15	0.38	0.50	....	....	....	....	....	....	....	....	....	....	....	2.76	2.28	2.00	....	....	....	....	....	....	....	....	....	....	....
Aug. 15, '09	.....	0.14	0.21	0.46	0.57	0.59	0.62	0.65	0.78	0.82	....	....	....	....	....	3.00	2.16	1.84	1.71	1.42	1.24	1.12	1.17	1.09	....	....	....	....	....
Sept. 3-4, '09	.....	0.26	0.46	0.54	....	....	....	....	....	....	....	....	....	....	....	3.12	2.76	2.16	....	....	....	....	....	....	....	....	....	....	....
July 6, '10	.....	0.14	0.34	....	....	....	....	....	....	....	....	....	....	....	....	2.40	2.04	....	....	....	....	....	....	....	....	....	....	....	....
Aug. 4, '10	.....	0.20	0.23	0.40	....	....	....	....	....	....	....	....	....	....	....	2.40	1.38	1.60	....	....	....	....	....	....	....	....	....	....	....
Aug. 8, '10	.....	0.10	0.19	0.33	0.46	0.47	....	....	....	....	....	....	....	....	....	1.68	1.62	1.44	1.38	1.13	....	....	....	....	....	....	....	....	....
Aug. 8, '10	.....	0.17	0.28	0.41	0.44	....	....	....	....	....	....	....	....	....	....	2.04	1.68	1.64	1.32	....	....	....	....	....	....	....	....	....	....
June 17, '11	.....	0.06	0.57	0.62	0.68	0.79	....	....	....	....	....	....	....	....	....	6.12	3.42	2.48	2.04	1.90	....	....	....	....	....	....	....	....	....
June 24, '11	.....	0.26	0.40	0.47	....	....	....	....	....	....	....	....	....	....	....	3.12	2.40	1.88	....	....	....	....	....	....	....	....	....	....	....
July 8, '11	.....	0.30	0.68	1.05	1.30	1.41	....	....	....	....	....	....	....	....	....	4.56	4.50	4.20	3.90	3.38	....	....	....	....	....	....	....	....	....
July 16, '11	.....	0.13	0.25	0.41	....	....	....	....	....	....	....	....	....	....	....	1.92	1.68	1.64	....	....	....	....	....	....	....	....	....	....	....
Sept. 8, '11	.....	0.19	0.40	0.58	0.67	....	....	....	....	....	....	....	....	....	....	2.52	2.40	2.32	2.01	....	....	....	....	....	....	....	....	....	....
Sept. 15, '11	.....	0.10	0.39	0.51	0.72	0.90	1.02	1.06	....	....	....	....	....	....	....	3.48	2.46	2.48	2.40	2.20	2.04	1.81	....	....	....	....	....	....	....
Sept. 15, '11	.....	0.07	0.16	0.28	0.38	0.47	....	....	....	....	....	....	....	....	....	1.44	1.34	1.24	1.20	1.13	....	....	....	....	....	....	....	....	....
Sept. 18, '11	.....	0.05	0.13	0.25	0.45	0.56	....	....	....	....	....	....	....	....	....	2.40	1.92	1.72	1.53	1.34	....	....	....	....	....	....	....	....	....
Oct. 6, '11	.....	0.15	0.47	0.65	....	....	....	....	....	....	....	....	....	....	....	3.84	3.00	2.60	....	....	....	....	....	....	....	....	....	....	....
Oct. 6, '11	.....	0.06	0.24	0.49	0.57	....	....	....	....	....	....	....	....	....	....	3.00	2.58	2.04	1.71	....	....	....	....	....	....	....	....	....	....
July 3, '12	.....	0.25	0.30	....	....	....	....	....	....	....	....	....	....	....	....	3.00	1.80	....	....	....	....	....	....	....	....	....	....	....	....
July 21, '12	.....	0.17	0.50	0.54	....	....	....	....	....	....	....	....	....	....	....	3.96	3.00	2.16	....	....	....	....	....	....	....	....	....	....	....
July 24, '12	0.01	0.09	0.24	0.27	0.29	0.33	0.34	0.57	....	....	....	....	....	....	....	2.76	1.44	1.12	0.90	0.82	0.96	0.98	....	....	....	....	....	....	....
Aug. 31, '12	0.08	0.15	0.34	....	....	....	....	....	....	....	....	....	....	....	....	2.28	2.04	....	....	....	....	....	....	....	....	....	....	....	....
Mar. 24, '13	0.01	0.14	0.28	0.35	....	....	....	....	....	....	....	....	....	....	....	1.68	1.68	1.40	....	....	....	....	....	....	....	....	....	....	....
June 18, '13	0.02	0.21	0.43	0.50	....	....	....	....	....	....	....	....	....	....	....	2.64	2.58	2.00	....	....	....	....	....	....	....	....	....	....	....
July 27, '13	0.01	0.16	0.30	0.43	0.58	0.61	....	....	....	....	....	....	....	....	....	1.92	1.80	1.72	1.74	1.47	....	....	....	....	....	....	....	....	....
Aug. 21, '13	0.00	0.18	0.20	0.25	0.43	0.63	0.79	0.91	1.01	....	....	....	....	....	....	2.40	2.38	2.16	1.98	1.83	1.62	1.55	1.52	....	....	....	....	....	....
Sept. 17, '13	0.08	0.13	0.25	0.49	0.52	....	....	....	....	....	....	....	....	....	....	2.88	2.16	1.96	1.56	....	....	....	....	....	....	....	....	....	....
Sept. 17, '13	0.63	0.05	0.14	0.41	0.64	....	....	....	....	....	....	....	....	....	....	3.24	3.00	2.36	1.92	....	....	....	....	....	....	....	....	....	....
Aug. 20, '14	0.01	0.17	0.30	....	....	....	....	....	....	....	....	....	....	....	....	2.04	1.80	....	....	....	....	....	....	....	....	....	....	....	....

Note—The figures in this column are inches of accumulated rainfall before the excessive rainfall began.
* July 11, 1897: Total of 2.56 in. fell in 56 min.; no rain for seven days before. In 4 hr., 1 min. 3.81 in. fell, a rate of 0.95 in. per hr.
† June 23 1901: Rain for 12 days before. Total of 2.3 in. fell in 2 hr., 55 min., a rate of 0.19 in. per hr.

Newark Terminal to Relieve Traffic Congestion

SYNOPSIS—The development of the business district and street-railway facilities of Newark, N. J., along two main arteries has resulted in great congestion. This article shows how the trouble will be removed by a double-deck railway terminal.

The development of Newark, N. J., has produced two main arteries of travel—Broad and Market Sts.—which have become so overcrowded with pedestrians, wagons, street cars, and motor vehicles as to interfere with the operations of the Public Service Railway Co. Practically all the street-railway lines in Newark converge on the "Four Corners," and close to 550 cars per hour are scheduled to pass through the intersection.

Development of Terminal Plan

Some relief was found by employing traffic policemen and by turning off a few cars where possible before they reached the intersection of these two main streets. But these were recognized as only partial remedies. The problem of an adequate solution was very difficult, since many of the railway's franchises provide that the cars must pass through the congested district and any proposition for extensive rerouting involved the nearly impossible task of rearranging the whole business district. The city, while having nearly 400,000 people, is not sufficiently developed to warrant extensive subway and elevated lines.

It should be noted that Newark is the center of a large, thickly settled district of about a million population served by the Public Service Ry., so that while the lines of the railway are politically interurban, the characteristics of the traffic on most lines are those of a very large distributed city—more like Chicago, Philadelphia, Boston, Milwaukee, St. Louis, Pittsburgh or Detroit than casual observation would show.

The key to the present scheme to eliminate the congestion on the lines of the Public Service Ry. was found by T. N. McCarter, president of the company, in 1912 while making an extensive tour of the country as president of the American Electric Railway Association. He was much impressed with the conveniences afforded by electric-railway terminals, especially in the West, and finally he became convinced that a terminal was the solution of the Newark problem—in spite of the fact that here was a decidedly urban railway development, while many of the Western terminals were brought into being by interurban traffic.

A site for a terminal was secured relatively near the junction of Market and Broad St., well inside the important business district. Thereupon the railway organization set out to devise a suitable track layout. Finally, a suggestion by Mr. McCarter that the terminal be separated into two floors led to the development of an acceptable arrangement. It was proposed that cars coming from the west should be brought to the terminal through a subway and should discharge their passengers on a subsurface level, going around a loop and returning by the same subway. Cars from the north, east and south would be brought in from the rear on an elevated floor, discharging their passengers, rounding a loop and returning in the same way. The approaches, track arrangements, etc., finally devised, are shown in Fig. 2.

The site also offered a fine opportunity for a large office building of the allied Public Service Gas, Electric and Railway companies—a convenience which was greatly needed. The design of the terminal and office building will be further presented in a second article.

A large number of changes in the street-railway tracks were required to make the terminal plans effective. These are shown in Fig. 1. The franchises for all this work constituted what was locally known as the "Twenty-Seven

FIG. 1. MAP OF NEWARK BUSINESS DISTRICT SHOWING STREET-RAILWAY CHANGES

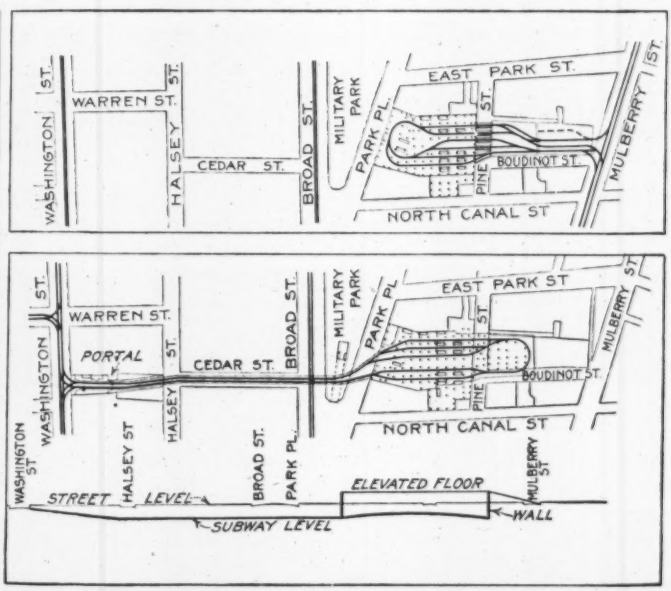

FIG. 2. TRACK ARRANGEMENTS FOR PUBLIC SERVICE RAILWAY TERMINAL

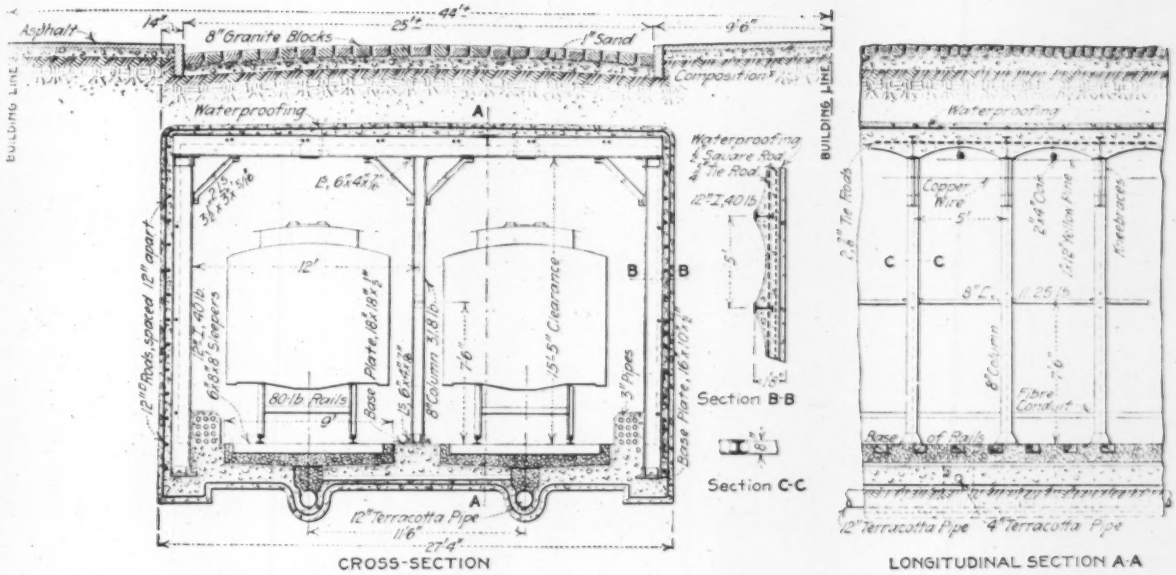

FIG. 3. SECTIONS THROUGH APPROACH SUBWAY; PUBLIC SERVICE RAILWAY TERMINAL, NEWARK

Group," and these were secured from the city, with the approval of the State Public Service Commission, after the legislature had passed an act enabling the company to build a subway and terminal on terms and under conditions prescribed by the Newark Board of Street and Water Commissioners.

These plans for the terminal were first presented to the mayor and board on Jan. 24, 1913. On Apr. 17, 1913, after broad publication of the plans, formal application was made for the 27 franchises. The first of these was approved Aug. 21, and the last on Sept. 18. The Public Utility Commissioners on Mar. 16, 1914, approved all the ordinances, after some changes had been effected in a so-called "Blanket Ordinance," containing general provisions. Ground was broken for the contractor on June 24, 1914. The cornerstone of the terminal was laid with appropriate ceremonies July 20, 1915. The terminal is expected to be opened for railway traffic and office occupation by May, 1916.

Subway Approach

A two-track subway approach to the terminal begins about two blocks west of the building with an open cut, on private right-of-way off Washington St. near Plum. The tracks gradually drop to the portal of the subway and shortly after cross under Halsey St. and are carried along and under Cedar St. to Broad. From here the line cuts across under Broad St., under the southerly point of Military Park and Park Place to the terminal.

A section through the subway is shown in Fig. 3. There is a clearance of 15 ft. between trolley wire and track, and the top of the subway is 4 ft. under all streets. A composite concrete-and-steel design was used on account of the restricted clearances, but even with this arrangement the outside walls extend 14 in. beyond the curb line. The clearance of a car from the inner walls will be 22 in. The subway was run as near the surface as possible, so that the bottom level would approach the bottom of the Morris Canal. This was done so that in case another subway should ever be built up Broad St., no extra difficulty would be imposed in clearing the present subway.

The track construction will consist of 80-lb. T-rail laid in 6 in. of gravel ballast on a concrete bed.

Under the park the tracks diverge. The ingoing tracks lead to two 280-ft. 10-car unloading tracks on the southerly side, and these again unite in a loop (50 ft. radius) connecting them with three 225-ft. 15-car loading tracks on the northerly side. These three finally converge on the outgoing track. Four stairways come up from the unloading tracks to the terminal concourse street level and six stairways lead down from the concourse to the loading tracks. There is a single stairway to the center platform which is not to be used for traffic.

Cars coming into the subway will stop for interchange of passengers before turning off Washington St. The outgoing traffic will also stop on the private right-of-way just east of Washington St., and here will be a small waiting room.

Elevated Approach

The tracks in the rear of the building turn off Mulberry St. at right angles and ascend to an elevated structure crossing Pine St., continuing at that level into the terminal. There are two six-car tracks on the north side, 140 and 170 ft. long. South of these and connected to them by a loop are three loading tracks, 190, 180 and 140 ft. long. The loop has a radius of 47 ft. Five stairways lead down from the unloading platforms to the concourse, and six stairways lead up to the loading platforms. A fourth loading track may be added if needed later to accommodate traffic.

An electric switch and block-spacing system will be installed for both subway and elevated tracks to segregate the cars on different lines and to secure prompt dispatching. There will be a double crossover in the subway under Military Park, so that a blockade on any of the terminal tracks will not tie up the whole system.

The height of the subway and both terminal floors allows the operation of a double-deck surface car if use of one should be found advisable.

It is expected that 400 cars per hour can be handled at the terminal, giving a capacity of 25,000 people per

hour in each direction, satisfying all traffic requirements for many years to come.

Concourse Floor

It is seen that by this design the two train floors are superimposed so that the unloading tracks of the subway are directly underneath the loading tracks of the elevated platform, and *vice versa*—an arrangement which is obviously convenient for the interchange of passengers.

From the subway floor to the concourse floor is 18 ft., and from the concourse to the elevated floor is 17 ft. This gives some passengers a total climb of 35 ft., which is to be compared with the following ones for New York City stations: 32 ft. for the Hudson Terminal at Fulton St.; 30 ft. for the Bronx subway station at 180th St.; 58 ft. from the Brooklyn Bridge subway platform to bridge-train platform; 40 ft. from the Pennsylvania Terminal train platform to the street and 43 ft. from the Long Island R.R. platforms to the street.

The separation of the facilities on two floors provides a clear space of 70,000 sq.ft. on the street level, which serves as an entrance and exchange concourse ample for the large crowds which will have to be taken out at rush hours. This level may be entered from Park Place, Pine St., North Canal St., and East Park St. In addition to the waiting rooms, lavatories, newspaper and candy booths and the office-building elevators, there will be here the showrooms of the commercial departments of the gas and electric companies.

Engineers and Contractors

The design and construction of the terminal and subway have been carried out under Martin Schreiber, Engineer of Maintenance of Way. The special staff for the terminal work has been headed by C. F. Bedwell, Assistant Engineer in Charge. Jacobs & Davies, of New York City, were the consulting engineers on subway and foundations; Geo. B. Post & Sons were the consulting architects.

The contract for the subway and the excavation under the building, with the foundations, retaining walls, etc., was let to the Holbrook, Cabot & Rollins Corporation, of New York City. The contract for the superstructure and remaining work was awarded to the Hedden Construction Co., of New York. The Hay Foundry and Iron Works was the subcontractor for the steelwork covered by both main contracts.

Better Looking City Railway Bridges in Philadelphia*

The improved designs that have been adopted in the Bureau of Surveys for the erection of artistic railway bridges, though started several years ago, are only now beginning to show appreciable results. A railroad bridge crossing a highway has a psychological value. If inartistic, constructed only for strength and utility, it creates the impression that a person is entering an industrial neighborhood where manufacturing interests have been given preference over all the factors that represent the culture and artistic taste of the community, and as such it seems to act as a barrier against the development along any other than commercial lines of the sections lying beyond.

Nobody ever desires to pass under an open trellis of a truss bridge, even though on the footway he may be protected by flashboards from annoyance due to dripping water. If, however, the bridge is constructed along artistic lines with at least as much attention to detail as would be spent on a residence or office building—a concrete-covered girder or cantilever arched bridge with its abutments ending in full sweeping curves and passing trains at least partially screened from view—it has a better effect upon the public. The artistic construction of bridges might reasonably be expected to result in the more rapid development of those sections to which access must be had by passage under the bridge. The same is also true where the highway has to be carried over the railroad line.

This comment on the matter of design in railroad bridges raises a general question. In all such undertakings we are undoubtedly spending entirely too little on the æsthetic features of the work. Our engineers and their assistants are employed principally to draw up plans and specifications to carry out work for purposes of utility. We put a premium on the smallest possible "first cost," and for structures which can be kept in repair at the least expense. Unfortunately it is easily conceivable that we might have all our construction work done at an exceptionally low first cost, and so as to require low maintenance charges and yet have a very inartistic city in which to live.

Through the influence of public-school education, art classes and splendid specimens of home building, our people are becoming more and more educated to the possibilities of artistic fitness in all kinds of structures. I think it would be a very popular move if councils should see their way clear to allow a certain percentage of the appropriations made for certain classes of construction contracts (that is, those for bridges, boulevards, buildings of all kinds, parks and open places and other such undertakings) to be expended for professional advice as to art and pure-design considerations. The public is unconsciously impressed by work that has been artistically designed and gives credit where in the absence of such a quality they just as unconsciously censure it.

Ultimately, of course, we should have here a division of design which will have as its main function everything that is done by this and perhaps other departments affecting the beauty of the city. Such a division should not have a large staff of regular employees. Perhaps its main function will be to organize its work so as to be able to lay its hands on the services of those best qualified to do a certain kind of original work at any given time and place.

The usual conception of the function of the Art Jury is that it was intended to fill this niche. This is absolutely wrong, and unless it is corrected will defeat the very purpose for which the Art Jury was created. The Art Jury is simply a critical division—one to comment on the work of others and to suggest the lines along which changes may profitably be made. An effort to combine with this a function of original design will put a burden on the Art Jury that will make it impossible to get the best class of jurors to serve. The functions of original design and of criticism must always be kept distinct if the best results are to be accomplished.

*From the 1914 report of M. L. Cooke, Director Public Works, Philadelphia, Penn.

Rebuilding Elevated Railways in New York City--II

SYNOPSIS—Concluding part of a description of elevated-railway rebuilding work costing over ten million dollars and requiring 50,000 tons of new steel. Summary of the changes made in the various portions of the line. The old express-train system, with long runs from the City Hall district to Harlem, is replaced by a system of operation with express stops about a mile apart. This required building new stations into the existing trackage.

It is interesting to see that as shown by the work now in progress the old structure has in many places sufficient excess of strength to support the 100 per cent. or more increase of loading without requiring reinforcement. In the case of the old single-stem construction on New Bowery, where a second deck with two tracks is being added (see *E*, Fig. 6, for an outline sketch and Fig. 1 for a view), the 15-in. two-channel columns have sufficient sectional area not to require reinforcing. However, the structure is provided with a large amount of new bracing. Transversely, the connection of the new cross-girders which support the upper deck reduces the free length of the columns; longitudinally, portal frames of truss construction are inserted between the columns as shown in the side elevation in sketch *I*, Fig. 6.

Bracing the Old Structure

Bracing was added at the 50- to 60-ft. high structure along Eighth Ave. near the 116th St. station (Ninth Ave. line). The towers here are of Phœnix columns with longitudinal and transverse portal diagonals and struts (the latter four-angle balloon struts), while transversely the deep pin-connected trusses carrying the track girders brace the columns. As these portal systems end some 30 ft. above the street, it was considered desirable (because the operation of through expresses would increase the impact and vibration) to add another panel of bracing, extending the bracing down to within minimum clearance height of the street. The result may be seen in Fig. 8. While the old struts and ties were attached to the columns by through bolts or pins, the attachment of the new members is made by a carefully devised riveted connection to the flanges of the column bars, the gusset-plates being notched around the old column rivets and fastened by new intermediate rivets.

Column and Girder Types

The old structure contains a picturesque variety of types of columns—Phœnix columns, two-channel latticed columns, columns made of four 6-in. I-beams set with their webs in radial planes and connected by cast-iron spreaders and cap blocks, etc. While all of these columns are in excellent condition and of ample strength for the normal service, many required replacement on account of the increase of loading. In some instances the old columns could be retained by strengthening a detail. In the case of the double-channel columns built with a spread head-portion (the channels being bent outward to form the head) the original latticing at the spread portion has been replaced by large side plates; thus reinforced, most of the columns proved ample for the increased loading.

The majority of the old track girders and many of the cross-girders were of truss construction, with angle web-members usually joined by two- or three-rivet connections to the legs of the flange angles without the use of gusset-plates. Most of the new construction is of the plate-girder type, as this is no more expensive in first cost than lattice construction and from the maintenance standpoint is cheaper in the long run. However, on the Bowery where the structure is being entirely rebuilt with three tracks over the street in place of two single tracks over the curbs, all tracks girders are of lattice type, to give more light and obtain uniformity. In some instances where lighting requirements made openings in the webs desirable, these are obtained by cutting holes in the plate-girder webs rather than by resorting to truss construction, as exemplified in Fig. 3, where such a perforated girder admits light to the windows of the mezzanine station.

General Summary of Work

Third Ave. Line—On Park Row leading north from the City Hall terminus, the old double-track structure has been replaced by a new four-track structure including a double-deck station at City Hall, inclines connecting the two decks, and with a single-deck four-track station at Chatham Square. The most vital change here is the elimination of the Chatham Square grade-crossing, where the Third Ave. and Second Ave. lines came together and the South Ferry and City Hall lines diverged, all formerly double-track. The plan in *A*, Fig. 6, shows the rearranged trackage. Practically all the structure here is new, except for some old longitudinal girders and a few old platform girders at the City Hall station.

On New Bowery, just south of the Chatham Square junction, the two old single-track single-column structures south to Franklin Square, about 1800 ft., have been altered into a double-deck four-track structure. Where the headroom for street traffic was sufficient, the two additional center tracks are carried by new cross-girders riveted into the sides of the old fan-top columns. Where the street clearance was not sufficient, the cross-girders for these two additional upper-deck tracks are carried on the tops of the old columns. The new center tracks ascend from a junction with the two old tracks near Franklin Square to the overhead crossing at the Chatham Square junction, whence they descend again, each track on a separate bent seated on the lower-deck cross-girders, until they join the lower-deck three-track structure at the south end of the Canal St. station.

Where these two new tracks pass over the old South Ferry branch station at Chatham Square, an additional upper-deck platform has been constructed between the two tracks, thus transforming this station into a double-deck structure.

The two single-track single-column structures in the Bowery for a length of about 5200 ft. north to Fifth St. are replaced by a five-track structure from Chatham Square north to Canal St., and by a three-track structure

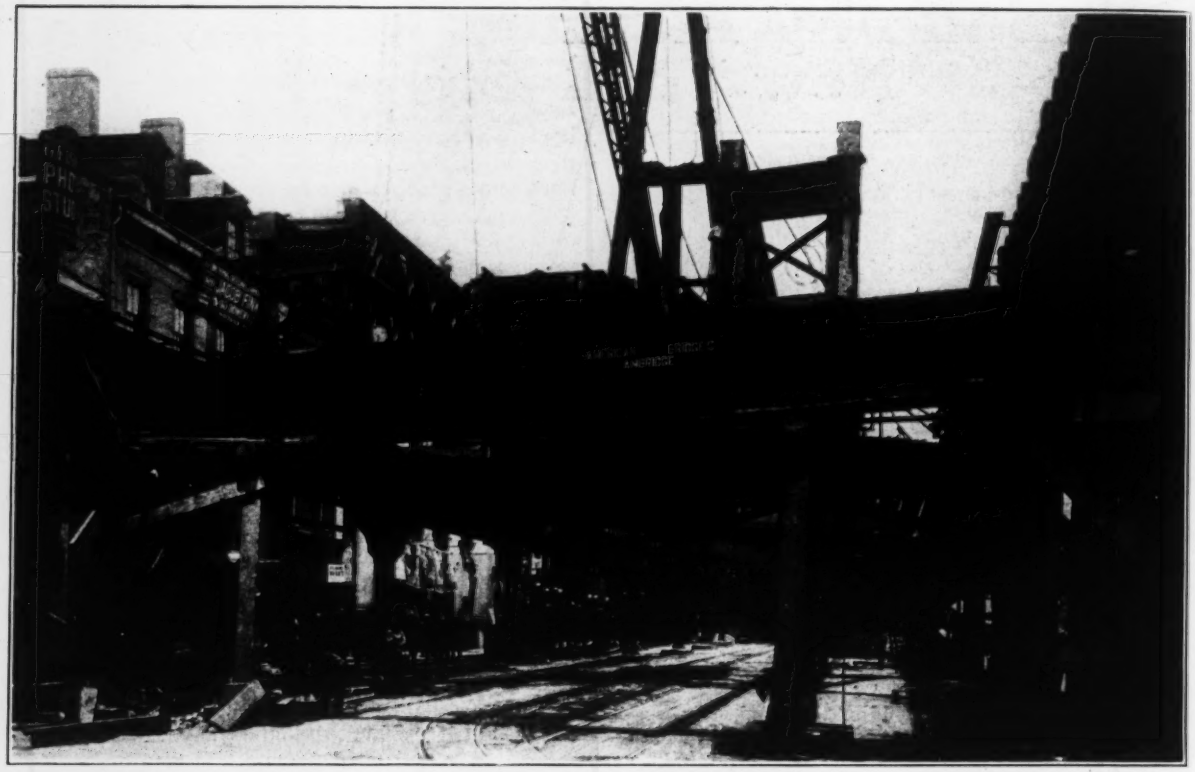

FIG. 10. NEW FIVE-TRACK STRUCTURE; BOWERY, SOUTH OF CANAL ST., MANHATTAN
Old structure, two single-track single-column lines. New columns at location of old columns

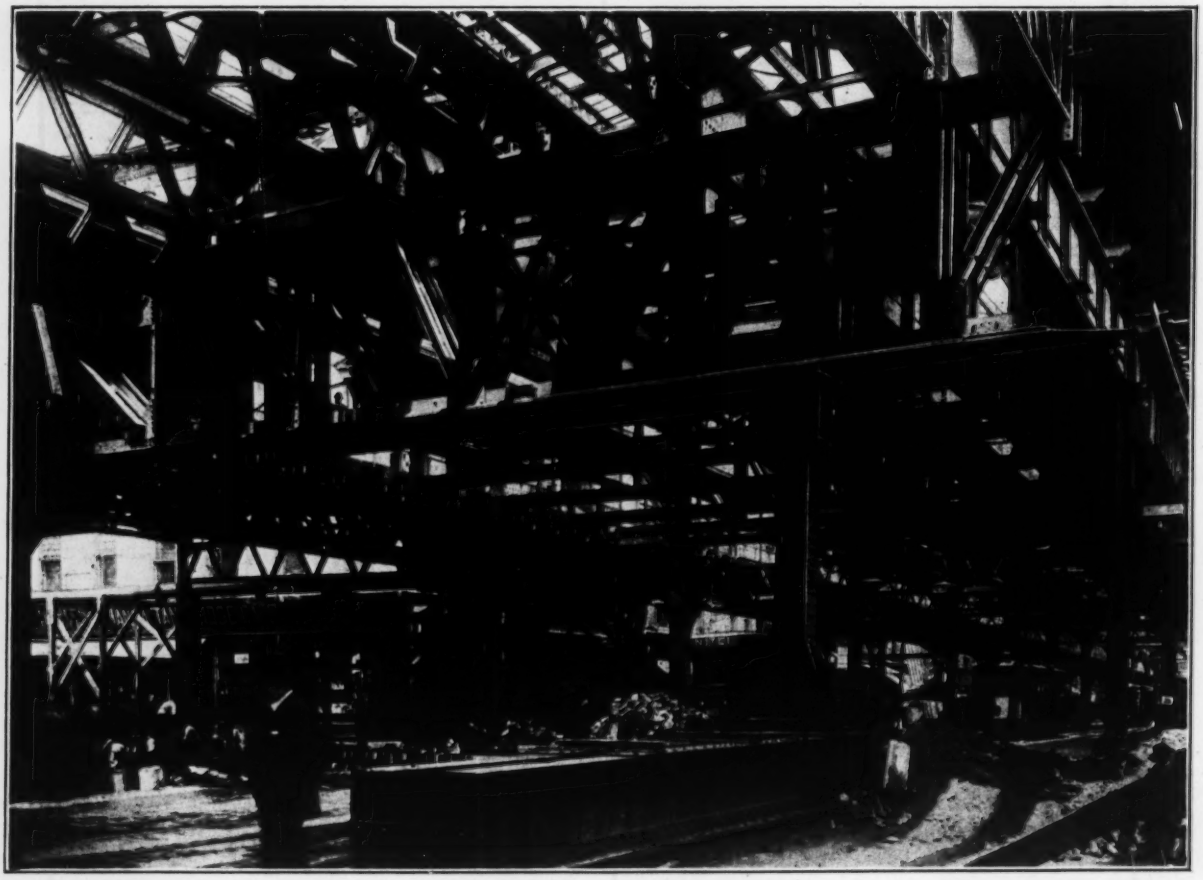

FIG. 11. MEZZANINE STATION FRAMING; CANAL ST. AND BOWERY; TRANSVERSE TRUSS ON TEMPORARY FOOTING

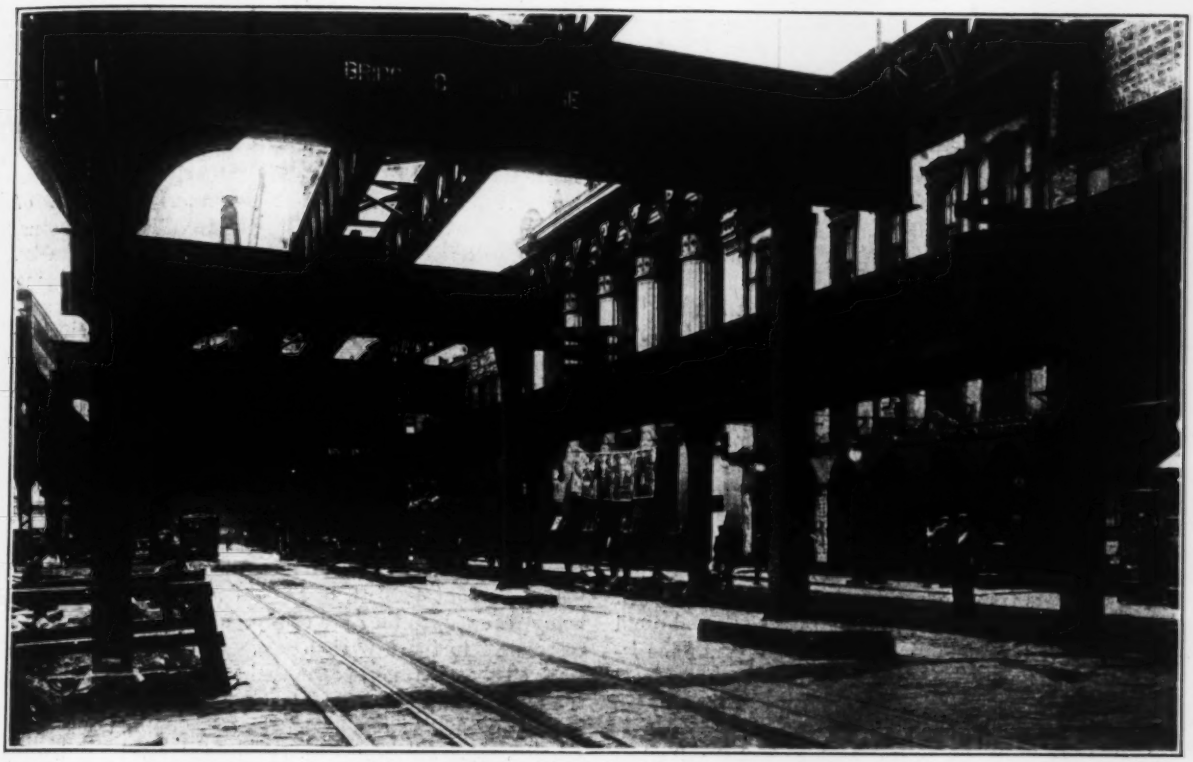

FIG. 12. NEW THREE-TRACK ELEVATED STRUCTURE ON THE BOWERY
Outer ends of cross-girders interfere with old structure

FIG. 13. BOWERY ELEVATED-RAILWAY STRUCTURE IN STREET; OLD STRUCTURE AT SIDES TO BE REMOVED
No interference with old structure at this point

thence north to Fifth St. The five-track structure is needed to carry the two overgrade tracks at Chatham Square station down to a connection with the lower-deck tracks. There are extensive interferences between the new and old steelwork in this section, making the work very difficult. Further, new stations are being built at Canal St., at Grand and Broome St., and at Houston St., all three being mezzanine stations with island platforms.

From Fifth St. north through the Bowery and Third Ave. to 116th St., a distance of 5½ mi., about one mile of center track has been laid to complete the express tracks. Stations of the "hump" type for the express track are being built at Ninth, 23rd, 42nd and 106th St.; this work includes the complete replacement of 35 bents and the raising of the center-track girders to form the hump, in addition to the work in the stations proper.

Second Ave. Line—The Second Ave. line from Chatham Square to 116th St. requires the construction of about 23,000 ft. of new middle track on new girders; the cross-girders in general are sufficiently strong. In this section the longitudinal girders have lips resting on top of the cross-girders, while on the greater part of the other lines the track girders frame into the webs of the cross-girders. Express stations are provided for at 14th, 86th and 42nd St., the former two of the hump type, the last of the island-platform type with mezzanine station. A local station at 92nd St. has been reconstructed for outside platforms.

North from 116th St. to the south end of the Harlem River bridge at Second Ave. and 129th St., the trackage is revised and track inclines built to form approaches of the express track to the upper deck of the new bridge. This involves renewing about one-half the columns and cross-girders in addition to constructing the upper-deck structure. The revision of trackage also involves spreading the running track and track girders while in service, on part of the line. The old station at 127th St., Second Ave., has been demolished and a new mezzanine station built at 125th St.

Replacement of the swingbridge and its two approach spans by new double-deck spans is now completed. The old piers were found ample to carry the new structure. The swingbridge was floated into place Aug. 22, 1915 (see *Engineering News* Sept. 2, 1915, p. 437), completing the transformation, the other spans having been floated in several months ago. In all cases the spans were built on falsework along the shore just south of the bridge and were lifted off by scows fitted with sandboxes on falsework; the raising and lowering of old and new spans to remove and place them was accomplished by the tide, hydraulic jacks, and the use of the sandboxes.

Third Ave. in the Bronx (Suburban Line)—North of the Harlem River bridge the two existing tracks are sufficiently far apart to admit of the old independent structure between them (which carries the New Haven shuttle connection), being supplemented by an upper deck to 132nd St. From here on to 133rd St. the express tracks are carried on an entirely new structure between the two old local track structures. North of 133rd St. the same construction is continued, but the westerly track of the present line has been shifted west under traffic 13 ft. on a length of 2600 ft. to make room for the new structure. The track girders carrying the southbound track were originally supported on masonry piers between 133rd and 143rd St.; new piers were constructed to support the southbound track while it was being shifted westward. Double-deck stations have been built at 133rd, 138th and 143rd St., replacing the existing stations.

North of 143rd St. the two upper-deck tracks merge into one at the lower level, and a three-track structure continues thence north to the end of the line at Fordham Road, about three miles. On the southerly two miles of this section it was necessary to replace all the columns, as they were not sufficiently strong to carry three tracks. Seven island-platform stations in this section are being rebuilt as stations with outside platforms (for local service only) and three island-platform stations are being rebuilt as express stations with two island platforms.

Ninth Ave. Line—The Ninth Ave. line required as its largest item of work the construction of a middle track for 10,500 ft. from Cortlandt St. to 14th St. About one-third of the columns required renewal. The old structure was composed of two single-column single-track structures on the curbs, and cross-girders existed only at stations. These cross-girders had to be renewed or reinforced, and for the rest of the line new ones had to be placed. About 4300 ft. of the old track girders are also being renewed, as they are of a peculiar type not adapted to connect to the new structure. In order to make the work on the old tracks possible, the center track had to be completed and southbound traffic diverted over it, thus permitting first one and then the other outer track to be rebuilt. For this purpose the center track, although its northerly portion later had to form an incline to the 14th St. station "hump," was first constructed on the level of the old track. After completion of the rebuilding of the outer tracks the northerly part of the center track was jacked up to the grade of the incline.

The stations at 14th St. and 34th St., which had outside (local) platforms only, have overgrade platforms added for the express track, and this track has correspondingly been raised to a "hump" at the station on new bents and new track girders.

Where the Sixth Ave. line joins the Ninth Ave. line, at 53rd St., the express track of the Ninth Ave. line crossed the southbound Sixth Ave. turnout track at grade. This crossing has been improved by elevating the center track over the crossing. A number of the cross-girders and columns were renewed in connection with this work, on account of the increased stresses in the structure resulting from the higher position of the express track.

At 66th St. and 145th St. the existing local stations are being rebuilt into hump stations like those at 14th St. and 34th St.

At 116th St. and 125th St., the outer tracks have been spread 6 ft. and 5 ft. 9 in. respectively, and the center platforms, which formerly interrupted the middle track, have been moved and lengthened and now form island platforms constructed between the southbound and middle tracks and between the northbound and middle tracks alternately, with the adjacent ends sufficiently separated to enable the middle track to run through. In connection with this work a considerable amount of bracing is added to the towers supporting the structure between 114th and 117th St., where the roadbed is about 60 ft. above street level. The mezzanine concourse at the 125th St. station required enlargement, while at 116th St. the old stations formerly at the inside ends of the platforms at

track level have been removed and a new mezzanine station constructed at the level of the passage from the elevator.

The present terminal of the Ninth Ave. line at 155th St. and Eighth Ave. has been almost completely rearranged as to trackage and gradients, yard tracks have been added, and the roadbed has been raised 4 ft. on the average to admit a mezzanine station below and enable a new mezzanine station to be built at 157th St. (alongside the baseball grounds). The old east and west stations at 155th St. have been abandoned as stations; they will be used by the trainmen for other purposes. An entirely new commodious station was built just north of the 155th St. Viaduct with stairs leading up to the viaduct and down to two new island platforms which extend northward to the 157th St. mezzanine station. The new mezzanine station near 155th St. is located below the south end of these platforms.

The existing connections with the New York & Putnam R.R., running north from this point on an elevated structure and crossing the Harlem River to its suburban line northward, will be maintained, but the line from 157th St. across the Harlem River will be taken over by the Interborough Rapid Transit Co. and a new line built eastward from the north end of the bridge to connect with the new city elevated railway on River Ave.

Figures and Names

The total weight of new steelwork involved in the elevated improvements is a trifle over 50,000 tons. The entire enterprise includes, besides the work outlined in the foregoing pages, two extensions, and two connections: (1) A connection to the Queensboro Bridge from the Second Ave. line at 60th St., involving also considerable rearrangement of the trackage on the Second Ave. structure for some distance south of 60th St.; (2) a connection with the West Farms elevated section of the present Interborough subway diverging from the Third Ave. line at about 143rd St.

The entire work has been planned throughout by, and is being carried out under the supervision of George H. Pegram, Chief Engineer of the Interborough Rapid Transit Co. F. W. Gardiner is Principal Assistant Engineer, and S. Johannesson, Assistant Engineer of that company.

The construction organization consists of a temporary association of three contracting concerns, T. A. Gillespie Co., Terry & Tench, and the Snare & Triest Co. The associated affairs are managed by E. J. Govern of the T. A. Gillespie Co. The construction work between these three is divided as follows:

The Gillespie Co. handles all the foundation and all station reconstruction (other than that portion of station reconstruction handled by Snare & Triest), except for the supporting steel. The Snare & Triest Co. carries on all erection and reconstruction work other than foundations on the Ninth Ave. line from 66th St. north to 145th St., and on the Third Ave. line from 149th St. north. Terry & Tench are handling the erection and reconstruction on the other portions of the Ninth Ave., Second Ave., and Third Ave. lines.

Work was begun on Mar. 25, 1914, and at the present time is 85 per cent. completed. Already trains are running over some of the revised tracks, although complete service has not been established.

Old Wooden Turbine Tested

By Clinton B. Stewart*

During the period 1850-60, while the American type of hydraulic turbine, inward and downward flow, was being developed, many wooden turbines were built for small powers by ingenious millwrights, employing some of these same ideas. The general principle was to use a central downward-discharge chamber which contained a paddle wheel made of flat blades revolving about a vertical axis, the water being admitted to the chamber through a single scroll entrance or several curved guide passages equally distributed around the circumference of the casing.

No reliable records of tests on such a turbine have been found, but the drawings of one used at Wausau, Wis., from 1858 to 1877 have been preserved and a full-sized model was made and tested. The results of these tests are

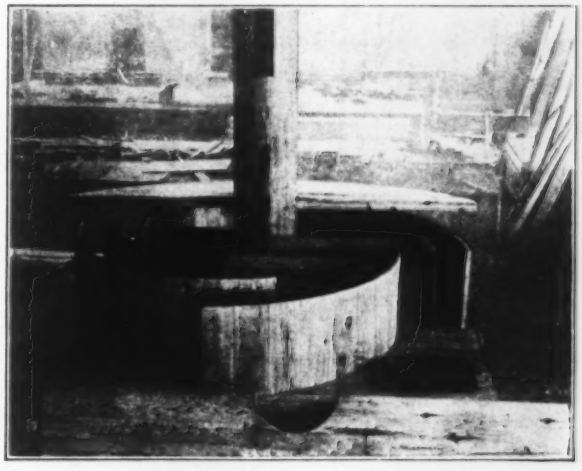

FIG. 1. MODEL OF OLD WOODEN TURBINE

given in the following paragraphs, as being the nearest possible approach to knowledge of the performance of the old machines.

Model of Old Wooden Turbine

This turbine was used to drive a "run of stones" by means of a belt from the vertical turbine shaft to the vertical mill shaft.[1]

Fig. 1 is from a photograph of the model, and Fig. 2 shows the details and flume setting for tests. It will be seen that the runner was made by bolting four 2x12-in. planks, about 2 ft. 2 in. long, to a 12-in. vertical shaft,

*Consulting Hydraulic Engineer, Madison, Wis.

[1]A common practice when this turbine was installed. A "run of stones" signified a circular pair, 3 to 5 ft. in diameter, the upper one revolving with the vertical spindle and the lower one being stationary. Water-power grants frequently included the right to sufficient water to drive a stated number of runs of stones. The American type was developed largely as a result of the demand of the grain-milling industry and it displaced the Fourneyron outward-flow and Jonval axial-flow types. These had supplanted the breast, overshot and curved-blade undershot wheels, which had been developed from the primitive flat-vane undershot impulse wheels. The breast and overshot wheels reached an efficiency of 60 to 80 per cent., compared with the 20 to 30 per cent. of their prototypes; but the difficulties of fluctuating tail-water remained unsurmounted until the Fourneyron outward-flow type (1827), the Fourneyron inward-flow type, Howd wheel (1838), and the Jonval axial-flow type (1840) appeared—utilizing the reaction principle and working submerged. These gave good efficiencies and were used up to 1860 in the larger installations. But they were comparatively expensive and did not find general service in small plants. Apparently up to about 1860, when the iron runner with double curved buckets was introduced, there was no simple, inexpensive turbine for small powers and low heads which would work submerged with an efficiency above about 30 per cent.

allowing the end of each plank to project beyond the side of the shaft about 12 in. There were four curved guide passages, rectangular in cross-section, for the entrance of the water, so arranged that the inner end of one guide overlapped the outer end of the adjoining guide. At the entrance of each guide passage there was a butterfly valve, as shown, and an arrangement by means of a collar around

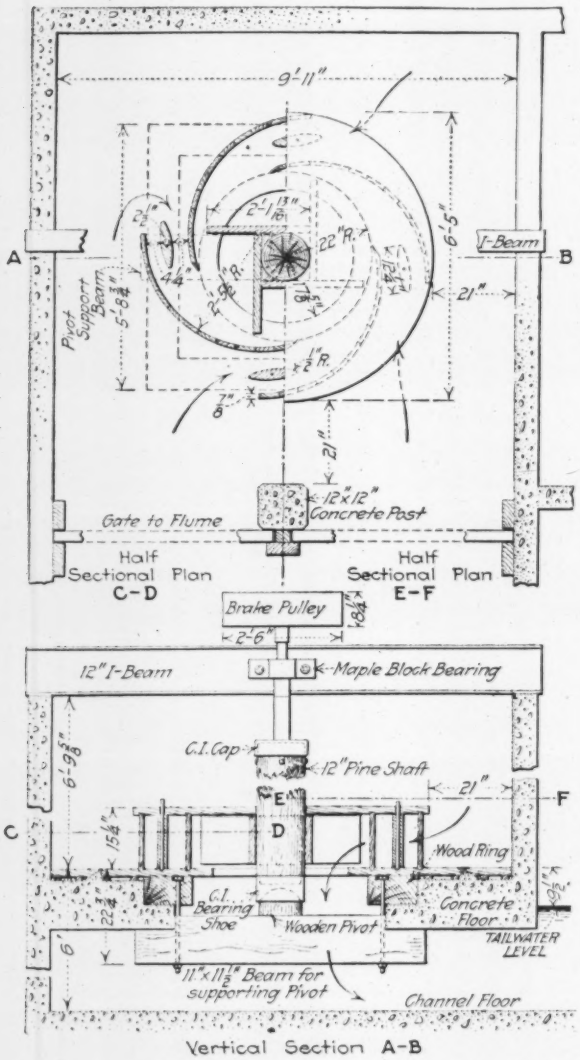

FIG. 2. TURBINE DETAILS AND TEST ARRANGEMENT

the shaft whereby all valves could be closed or opened by a wrench. The opening in the flume floor through which the water was discharged was circular, the radius being about 4 in. less than that of the circle described by the outer ends of the planks forming the runner. It was evidently intended to act as a submerged impulse wheel rather than to obtain any benefit from reaction.

Tests and Their Results

The object of the tests was to determine the amount of water used, the power developed by the turbine and the efficiency, under hydraulic conditions duplicating as nearly as possible those in the mill. The discharge of the turbine was measured by means of a submerged orifice 4 ft. square, placed in the flume leading to the turbine, which had been carefully calibrated by the writer in 1908.[2] The horsepower was measured by means of a prony brake.

The results of this test are shown by Fig. 3, which gives the relations of speed to efficiency, power and discharge. It will be noted that the maximum efficiency under the best working conditions was about 27 per cent., while the maximum power developed at the turbine shaft was about 6.4 hp.

In order to determine the approximate loss in the bearings and the effect of this loss on the efficiency, a test was made of the starting torque. This test showed that 15 lb. on the 3½-ft. arm of the prony brake was required to start the turbine. Using this torque as a measure of the friction during motion the results indicate that not more than about 8.7 per cent. of the total power was absorbed in the bearing, and that the hydraulic efficiency was about 30 per cent. With an allowable 5 per cent. loss in the bearings, the actual efficiency would have been about 28 per cent.

Tests were also made with the tail-water lowered so that air was admitted freely under the flume floor. The results showed that there was no measurable change in the efficiency of the turbine.

The cause of the low hydraulic efficiency of 30 per cent. is quite evident. When a jet of water impinges normally on a moving plane surface, not over one-half of the energy of the jet can be transformed into work. The vanes of the runner were formed of plane surfaces, were few in

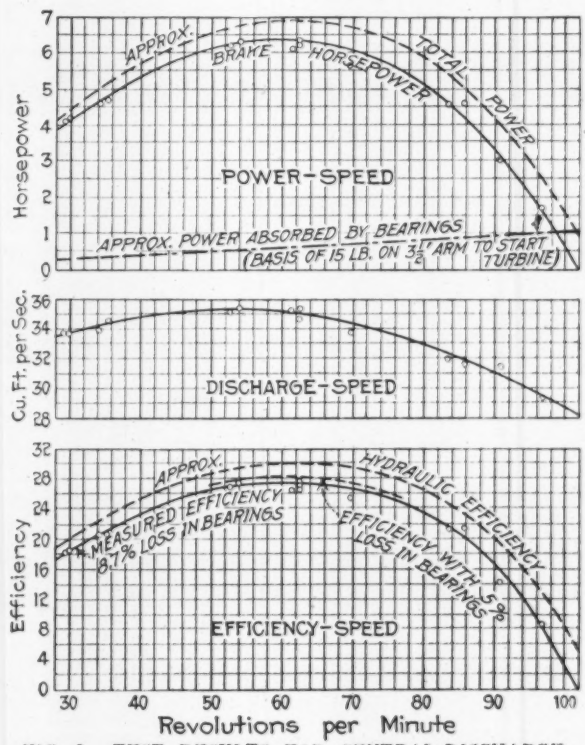

FIG. 3. TEST RESULTS FOR CENTRAL-DISCHARGE WOODEN TURBINE

Headwater, 5 ft. deep in flume; tailwater, 0.8 ft. below flume floor; effective head, 5.8 ft.; gates wide open

number and so arranged as to cause a large loss of energy because of sudden change of velocity and impact at entrance.

The tests were made in the hydraulic laboratory of the University of Wisconsin, to the officers of which credit is due for the use of instruments and facilities.

[2] "Bulletin No. 218," University of Wisconsin.

City Planning in Queens Borough, New York--II

By Frank B. Tucker*

SYNOPSIS—The preparation of the tentative map, surveys for the final map, the final map and what data it contains—all these details of practical city planning in a rapidly growing community are described.

The numerous preliminary details in connection with the laying out, widening and discontinuing of streets in the Borough of Queens, New York City, having been discussed in *Engineering News*, Sept. 30, 1915, the present article is confined to the engineering work of establishing the predetermined city plan.

Tentative Map of the Borough

Upon the assembled reproductions of the planetable (sheets of the original topographic survey) is laid out the proposed street system as determined after a careful study of the many legal and engineering considerations, and of other facts requiring investigation before committing the city to a definite street plan. The design is then carefully plotted on a scale of 1 in. = 200 ft. on the mounted sheets themselves, and a tracing made.

To this tracing is given the appellation "Tentative Map" (Fig. 1 is a small section). It is formally adopted by the city Board of Estimate and Apportionment, and thereafter is available to the public on a scale of either 400 or 800 ft. to the inch (to which scales it is photolithographed) for a very nominal charge.

The complete Tentative Map of the Borough of Queens will consist of 14 units, separately prepared but collectively studied, varying in the areas comprehended from 1000 to 8450 acres. Of these, 13 have already been completed; the 14th, which is for the lowland adjacent to Jamaica Bay, will be completed this year.

The Tentative Map is an effort on the part of the city to control its future growth. It is intended as a warning and a guide to real-estate developers and promoters as to the lines along which they must develop their property if they would have the city take official cognizance of their streets. While it gives no block dimensions, it is accurately drawn to scale, and is readily adaptable to locating new streets.

Making Surveys for Final Map

Any real-estate developer or promoter who disregards the Tentative Map and lays out his property to suit his own immediate ends is inviting future trouble for himself and for all who may purchase property from him, for the city is determined to exercise surveillance over the opening of all new streets; and while there is no compulsory legislation requiring property owners to observe the Tentative Map, the fear that the city will otherwise omit their streets from its final map has a most salutary influence.

Coincident with the preparation of the Tentative Map has proceeded the preparation of the Final Map (of which Fig. 2 is a small section). The preparation of this map is quite different from that of the Tentative Map, which is based upon the planetable and traverse survey of the existing streets, and is devoid of dimensions other than street widths and tentative grades. The Final Map is based upon an accurate property survey of each and every existing street to determine its true relations to abutting private property and to every other street; it is replete with dimensions.

For the survey for the Final Map all the data obtainable are secured. The deeds, the sale and survey records and the old road maps on file with the county clerk or elsewhere are carefully studied and such information gleaned therefrom and from private surveyors and title guarantee companies as will be of assistance in picking up street lines upon the ground. But no matter how complete the data gathered from these sources may be, the real work must be done upon the ground with transit and tape.

First, average lines are independently picked up on each street and compared with each other to see how they hold to the private property dimensions given by deeds and sales maps. Then it becomes a case of cut-and-try until the line of each street is determined beyond all question.

Street Monuments; Map Computations

When this line is obtained, it is marked with granite monuments 4 ft. long with a minimum square cross-section of 8 in., to which dimensions their tops, with side drafts of 2½ in., are dressed. In general, monuments are set every other block along the short dimension of the blocks and every block along the long dimension.

Deciding the best offset from the building line upon which to set monuments has proved something of an enigma. In old Long Island City, which was monumented in the seventies, a 5-ft. offset was used. With a view to clearing building appurtenances which often encroached this much beyond the building line, preventing a direct sight between monuments, the Topographical Bureau during its early experience used an 8-ft. offset, but this was found to fall within the catchbasin area, so the 5-ft. offset was resumed.

All preliminary measurements to determine the location of monuments are most carefully made by the method described in the article entitled "The Method and Apparatus for Chaining Used in Topographical Bureau, Borough of Queens," by George J. Falkinburg, *Engineering News*, page 291, Mar. 14, 1907. Angles are measured by 12 repetitions.

Computations for Final Map

When the survey of an area is completed the results are turned over to the computers for adjustment, coördination and the determination of block dimensions. The results of the fieldwork as received by the computers is usually a plot showing all monuments, with the angles and distances between them, together with the field-books, that the plot may be verified.

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The adjustment of the monument traverse is the first and most difficult part of the computations. Adjustment is a matter of experience and judgment, the common proportional methods of traverse balancing being applicable only to a limited extent. There is a gridiron system of monument lines, running through every street or every other street, which must be whipped into proper relationship with the other systems, and with similar lines in sections already adjusted—due consideration being given to their subsequent connection with monument lines yet to be run. The demands of widely separated communities for final maps make it impossible to prepare the final map as a unit.

No rules can be laid down for effecting these adjustments. The procedure is to make all possible tests to prove the accuracy of the fieldwork, and then make such shifts and swings in the monument lines, both individually and collectively, as the tests indicate will more closely approximate actual conditions and make the whole survey consistent with itself and its measurements mathematically correct.

When the adjustment is completed a traverse is run through all the monuments to test the accuracy of the adjustment and for the determination of the coördinates of all monuments.

The block dimensions are next determined by reduction from the monument lines, and where already subdivided, are carefully compared with the private sales maps to see that private property is not affected. Any surplu or deficiency that may be discovered is distributed *pro ra* among the blocks. In almost every case, there is a surplu resulting principally from the fact that until quite r cent times most of the surveyors in the borough used standard that was an inch longer per 100 ft. than th United States standard.

Drafting the Final Borough Map

When the computations of a given section are com pleted, a rough-draft working sheet with all dimension goes to the drafting room where a careful plat of it i made to a scale of 1 in. = 80 ft. upon mounted sheets, 31x53 in. The monuments are first plotted by their coördinates in the Tenth Ave. and 225th St. system (described in *Engineering News*, Sept. 30, 1915), and then connected. From the monument lines the blocks are drawn in by their offsets. These mounted sheets are then taken in adjacent predetermined pairs, and a finished tracing made.

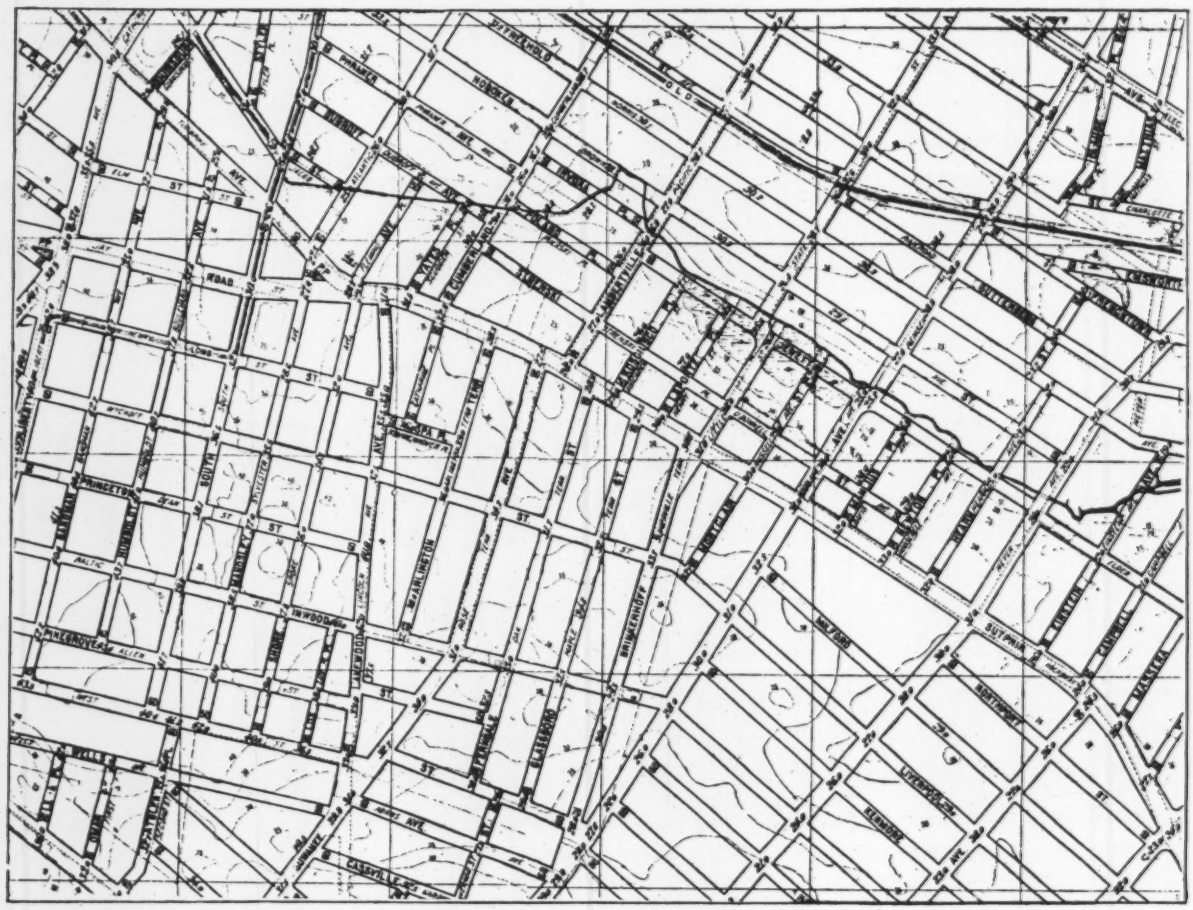


FIG. 1. SECTION OF THE TENTATIVE MAP OF THE BOROUGH OF QUEENS, NEW YORK CITY

Completing the Final Map

This tracing (Fig. 2) is a sectional unit of the final map of the Borough of Queens, and fulfills the charter requirements for the area it embraces. Each section covers an area of approximately 367 acres, and is numbered according to the predetermined system for identification and for cross-reference with adjacent sections.

Upon its completion, each section is sent to the Board of Estimate and Apportionment for approval, following which it becomes the final and authentic plan of the lines and grades of the streets shown thereon, and as such, certified copies are filed in the several offices of record required by the city charter; namely, the county clerk's, the corporation counsel's and the borough president's. For general use, for the purpose of filing and for sale to the public, each tracing is photographed down to a scale of 1 in. = 200 ft., and at this scale makes an atlas sheet 24½ in. square.

The importance of the Final Map lies in the fact that no street improvements are made by the city in its absence. On it also is predicated the legal proceedings followed by the city in acquiring title to its streets under its statutory right of eminent domain—a mete and bound description of each street as laid down on the Final Map forming part of the court's record.

To date 74 sections (about ⅓ of the Final Map) have been completed, besides numerous special final maps of small areas and of single streets, necessitated by some exigency. In the interest of economy or to facilitate industrial enterprises, maps altering the final map are from time to time made. Certified copies of the revised maps, of course, are filed in the several offices of record as outlined in a preceding paragraph.

C. U. Powell is engineer in charge of the Topographical Bureau of the Borough of Queens and L. M. Schoonmaker is principal assistant engineer.

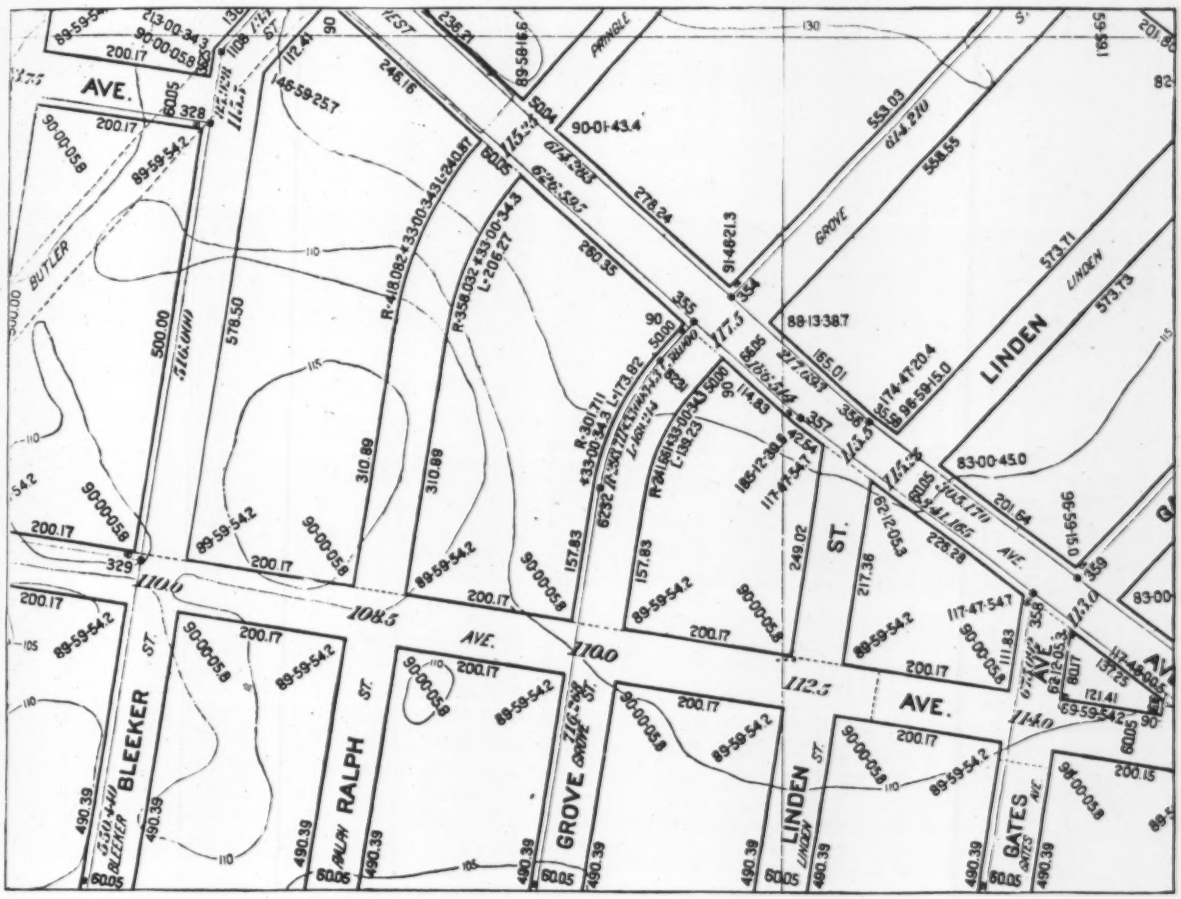


FIG. 2. SECTION OF THE FINAL MAP OF THE BOROUGH OF QUEENS, NEW YORK CITY

Daily Surveys on Panama Slides

The continued slides along the Gaillard cut on the Panama Canal have made it necessary that daily surveys of the canal sides and bottom be made there in order to keep the authorities informed as to the state of the channel. The *Canal Record* reports the details of these surveys as follows:

Three field parties leave Paraiso every morning at 7 in launches, proceed to their respective parts of the 2,800-ft. section in question, run transverse lines of soundings every 50 ft., making soundings on each line at intervals of 15 ft. from water's edge to water's edge, an average of about 300 ft., plot the soundings, trace the 5-ft. contours determined by them, and submit completed blueprints before 10 a.m. This requires rapid methodical work, and it has been calculated that the field parties, through their developed proficiency, require on the average approximately seven-tenths of a second to drop the lead, read the sounding, raise the lead and cast it for the next sounding.

The contour chart that results from this survey indicates the status of the channel and reveals the points at which extra effort is required. Copies are placed in the hands of the resident engineer, the superintendent, and the supervisor of the Dredging Division, another copy is sent to Balboa Heights for the information of the Governor and the Marine Superintendent, and a fifth is filed with the office records.

As soon as the soundings are completed, four drag parties proceed to drag the channel for bumps that do not show on the cross-section soundings. This dragging is carried on until after the passage of the commercial shipping. By such means it is possible to determine to the inch the depth of the channel; ships are held up or passed on the information received; every inch of the buoyed channel is covered; and the dragging between the passages of shipping takes care of changes that may occur.

This work, as well as the dredging, is carried on every day, including Sundays and holidays.

Albany Sewage-Disposal Works

By John H. Gregory*

SYNOPSIS—A pumping station, grit chamber, Imhoff tanks and sludge-drying beds are being built to prevent a visible nuisance and sludge deposits. The 16 Imhoff tanks have a nominal capacity of 30,000,000 gal. a day.

The City of Albany, N. Y., has under construction a sewage-disposal works for treating the dry-weather flow of sewage as recommended in a report[1] submitted to Wallace Greenalch, Commissioner of Public Works, by Hering & Gregory, of New York City, in July, 1912. The works are being built to prevent a continuation of the offensive conditions in the Albany Basin, a small land-locked harbor which the city is now improving at considerable expense, and also the excessive pollution of the Hudson River in general along the Albany waterfront. To accomplish this result the following recommendation was made in the report referred to:

> That the dry-weather flow of sewage of the City of Albany be collected and carried to one central point and there treated to such a degree as to remove suspended matters which would float on the surface of the water and be displeasing to the eye or which would settle on the bottom and banks of the river and form objectionable sludge deposits, and that the clarified effluent be discharged into the Hudson River off Westerlo Island.

It was not considered necessary to provide, at the present time, for a higher degree of purification, as the ordinary dry-weather flow of the Hudson River at Albany is many times the volume of the sewage to be treated.

The works needed to carry out the recommendation cited consist of a main intercepting sewer along the river front, with connections to the existing sewers, practically all of which have been built on the combined system; a small pumping station for pumping the sewage from a district which would not drain into the intercepting sewer except by lowering the sewer at excessive cost; a grit chamber and main pumping station at the end of the intercepting sewer, for pumping all of the sewage to the sewage-disposal works; and a sewage-disposal works consisting of Imhoff tanks and sludge-drying beds.

The plans and specifications for the sewage-disposal works were prepared early in 1912, but owing to unavoidable delays in securing rights-of-way construction did not begin until July, 1914.

The works now under construction have a capacity of treating an average volume of sewage of 30,000,000 gal. per 24 hr. but are designed to handle the sewage at a maximum rate of 45,000,000 gal. per 24 hr. The present population of Albany is about 108,000, but the plant has been designed to serve a population of 150,000 with a sewage flow of 200 gal. per capita per day.[2]

*Of Hering & Gregory, Consulting Engineers and Sanitary Experts, 170 Broadway, New York.

[1]"Engineering News," Aug. 22, 1912, p. 373.

[2]The water consumption in Albany in the year immediately preceding that in which the sewage-disposal works were designed was about 242 gal. per capita daily. In the report previously referred to it was recommended strongly that all water services be metered (at that time only 26 per cent. were metered), not only to reduce the waste of water but also the volume of sewage to be handled. While it is confidently expected that the water consumption per capita will sooner or later be materially reduced it was not considered advisable to design the sewage-disposal works for a flow less than 200 gal. per capita per day. Should the flow be reduced below this figure the disposal works will be able to serve a population greater than 150,000.

The sewage-disposal works are located in Bethlehem Township, on Westerlo Island, immediately adjacent to the southeast corner of the city and separated therefrom by water known as Island Creek. The city has purchased here about 75 acres of land on which the works are being built. Sufficient land has been secured not only for the present plant but also for its extension in the future, as well as for the construction of sprinkling filters should a higher degree of treatment be needed at some later date.

The ground at the site of the works is several feet above mean high water in the river, the Hudson River at Albany being tidal, with a mean rise and fall of the tide of about 2.8 ft., but is below maximum flood level. In order to protect the works from flooding they have therefore been surrounded by a levee, a portion of which has been made use of in the construction of the Imhoff tanks.

On reaching the pumping station the sewage will first pass through a grit chamber and will then be pumped through a reinforced-concrete force main to the settling tanks. These tanks, which are of the Imhoff type, are 16 in number and are arranged in four groups of four each. Fig. 1 shows a plan of one group together with longitudinal and cross-sections.

Each tank will have one large settling chamber and four sludge chambers, the two sludge chambers adjacent to each other at each end of the tank being connected by an opening in the dividing wall so as to equalize the accumulation of sludge in the two chambers.

When handling 30,000,000 gal. of sewage per 24 hr. and with all 16 tanks in use the settling chambers provide an average detention period of 3 hr. The sludge chambers are designed to hold an accumulation of sludge from a population of 150,000 for an operating period of from six to seven months.

The tanks are rectangular in plan, each being 33 ft. wide, 98 ft. long and having a total depth of 27 ft. 2½ in. measured from the water line in the settling chamber to the bottom of the sludge chamber. From the water line to the slot at the bottom, the settling chambers have a depth of 13 ft. 11½ in.

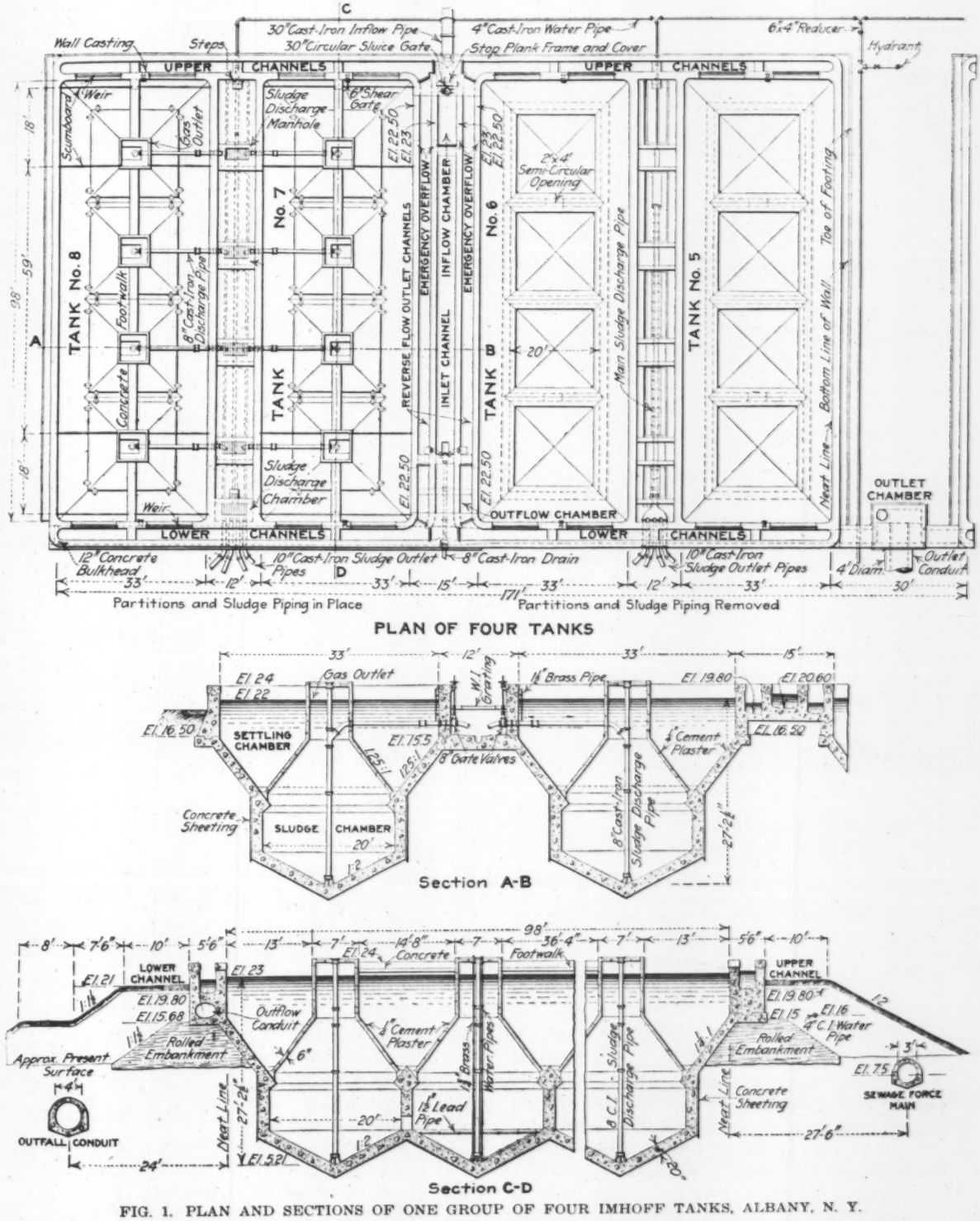
Over each sludge chamber, which is 20 ft. square inside, a gas outlet is provided, consisting of a hollow truncated square pyramid surmounted by a hollow shaft 6 ft. square inside and extending 2½ ft. above the water line. For convenience of inspection and operation the gas outlets in each tank are connected one with another and with the ends of the tank by a reinforced-concrete footwalk 2 ft. wide, located on the center line of the tank 1 ft. above the sewage level. Similarly, a footwalk of the same type of construction has been provided inside of and at the top of each gas outlet. By means of these footwalks all parts of the tanks that cannot be reached from the outside are made accessible.

The sewage enters each group of tanks at the inflow chamber, from which it passes into the upper channels. From the latter it enters the tanks over a set of submerged weirs. After passing slowly forward in a horizontal direction through the tanks the settled sewage is discharged at the outlet and over another set of weirs into the lower channels. Both sets of weirs are made

justable so as to distribute the flow of sewage as equally possible to all of the tanks.

From the lower channels the settled sewage passes into the outflow chamber and from there into the outflow conduits, which are built in, and as a part of, the walls of the settling tanks and lead to two outlet chambers. From these the settled sewage passes directly into the outfall conduit and flows thence to the river, where it will be discharged under water. Owing to contemplated improvements in the river by the Government the outfall conduit will, for the present, terminate at the outer edge of the government dike.

With Imhoff tanks having more than one sludge chamber it is well known that for the best results it is desirable, from time to time, to reverse the direction of flow through the settling chambers of the tanks in order that the sludge will accumulate at a more nearly uniform rate in the sludge chambers. The tanks have been designed to permit



PLAN OF FOUR TANKS

Section C-D

FIG. 1. PLAN AND SECTIONS OF ONE GROUP OF FOUR IMHOFF TANKS, ALBANY, N. Y.

of this method of operation. When thus operated the sewage from the inflow chamber will pass through the reverse-flow inlet channel direct to the lower channels and thence over the weirs into the tanks. After passing through the tanks in the reverse direction, the settled sewage flows over the weirs into the upper channels and

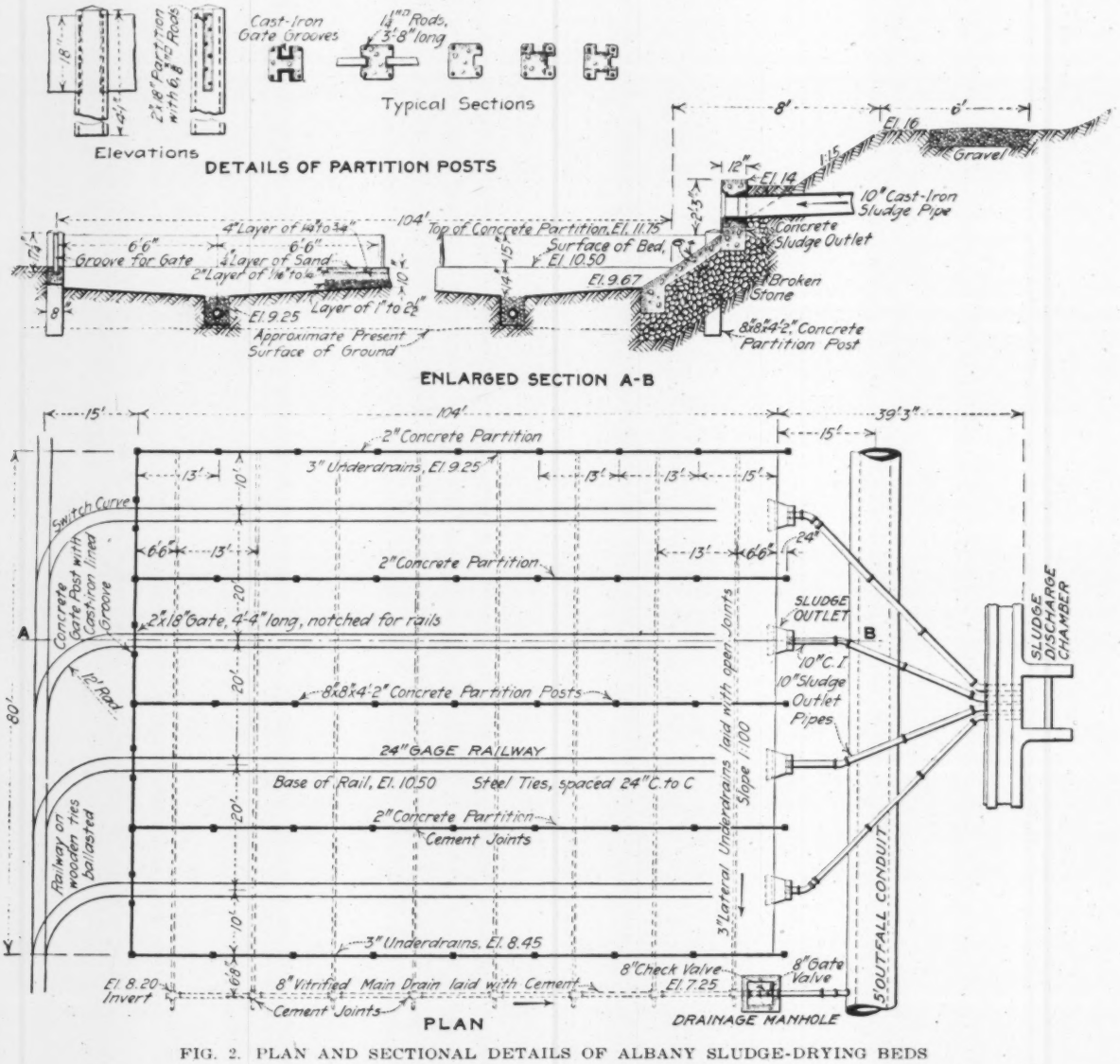


FIG. 2. PLAN AND SECTIONAL DETAILS OF ALBANY SLUDGE-DRYING BEDS

then through the reverse-flow outlet channels to the outflow chamber.

The direction of flow through the channels and tanks can be easily followed by an examination of the plan shown in Fig. 1. The total loss of head through the channels and tanks from the inflow chamber to the outlet chamber when the sewage is flowing in the reverse direction, and with a total rate of flow through the works of 45,000,000 gal. per 24 hr., will be about 1.2 ft.

The direction of flow through the tanks is controlled by means of stop planks held in cast-iron grooves. By means of sluice gates placed in the inflow chambers it is possible to shut off any group of four tanks, as desired.

All of the channels through which unsettled sewage flows to and around the tanks are open, have rounded corners, are readily accessible for cleaning and have been kept as small as seemed feasible. This is especially desirable, as it may be difficult to maintain at all points, under all conditions, sufficiently high velocities to absolutely prevent some slight deposition in the channels. Should deposition take place the material can be swept along and discharged into the tanks under water through openings provided especially for the purpose and without interrupting the flow through the tanks. When the reverse-flow channels are not in use they can be drained and emptied so as to prevent the holding of stagnant sewage and the production of offensive conditions.

Scum boards are provided at both the inlet and outlet ends and at two intermediate points in each tank. They are of reinforced concrete, are held in cast-iron grooves and can be raised or lowered or removed at will.

The water line in the tanks has been set at such an elevation as to put it above flood level in the river and also so as to provids sufficient head for the passage of the clarified effluent through sprinkling filters, should these be required at some later date. Owing to these

quirements the tanks are being built partly in excavation and partly in embankment.

The sludge chambers are of reinforced concrete. Sheeting, which is left in place, is being used for supporting the sides of the excavation while the chambers are being built.

The outer walls of the settling chambers consist of a heavy facing of concrete placed directly against the inner slope of a carefully made rolled embankment and carrying at the upper end of the slope a vertical concrete wall extending up 2 ft. above the water level in the tank.

From each sludge chamber the sludge is withdrawn through an 8-in. cast-iron pipe terminating in a sludge-discharge manhole, or shallow chamber, just outside of and built as part of the tank. The gates for controlling the flow of sludge are located in these manholes, but are controlled from above so that the operator will be able to see immediately the character of the sludge emerging from the pipe and will have full and rapid control of the whole process of withdrawing sludge. This is especially essential in order to avoid withdrawing partly digested sludge.

From the sludge-discharge manholes the sludge flows through a main sludge-discharge pipe, located between each two adjacent tanks, to a sludge-discharge chamber. From this chamber it is discharged to the sludge-drying beds through any one or all of four 10-in. cast-iron pipes, each of which terminates at the upper end of a sludge-drying bed. With the sludge-withdrawing facilities provided it is possible to withdraw sludge from any one sludge chamber of each two adjacent tanks and to discharge it on any one of four sludge-drying beds.

Ample water connections have been provided so that water under pressure is available at all points for flushing out sludge pipes, for forcing down possible floating sludge in the gas outlets of the tanks and for general cleaning and miscellaneous purposes.

The sludge-drying beds (located immediately adjacent to, but at a lower level than, the tanks, so that sludge can be discharged onto them by gravity) are 32 in number and have a total area of about 66,560 sq.ft. They consist of layers of graded gravel or broken stone, the coarsest material being at the bottom and the finest at the top, the average thickness of the bed being about 12 in. The top surface will at first be covered with a thin layer of coarse sand, but under ordinary conditions of operation the grit removed from the grit chamber will be used for this purpose. Details of one set of four sludge-drying beds is shown by Fig. 2.

The bottom of the sludge-drying bed will be graded into ridges and valleys, a 3-in. drain with open joints being provided in each valley. All the drains from each set of eight beds discharge into an 8-in. main drain, which in turn passes through a drainage manhole and discharges into the outfall conduit. In each of the drainage manholes, of which there are four, the main drain is provided with a check and gate valve to prevent sewage or river water from backing up, at times of high water in the river, into the underdrains and flooding the beds.

The several sludge-drying beds are separated one from another by thin concrete partitions held in position by concrete posts firmly set in the ground. This type of construction has been used in some other plants that have been designed by the writer and has been found to work out very satisfactorily. Not only is the material of a permanent nature, but the concrete posts and partitions present a very much neater appearance than do those of wood. While the first cost is a little more than that of wood, the additional expense is well warranted. The details of the concrete posts and partitions are shown in Fig. 2. This same type of construction is used also for the outer edge of the beds except along the sides adjacent to the settling tanks.

The sludge will be removed from the sludge-drying beds in small cars running on narrow-gage railway tracks laid at the surface of the bed. A track laid at the surface of the bed is not only cheaper but more convenient than one supported above. These tracks connect with a main track extending along the southerly end of the drying beds. The cars will be loaded by hand and pushed along the tracks from the sludge-drying beds to the main track and thence along the latter and up onto the levee and to the point of final disposal.

In designing the works the viewpoint of the operator has been constantly kept in mind, and the various details and arrangements have been carefully studied and worked out so to make all of the operations as simple and as convenient as possible for him.

The total cost of construction of the sewage-disposal works, including the outfall conduit to the river but not including the land, grit chamber and pumping station, based on the estimated quantities and contract prices, will be $277,302. With a population of 150,000 and a sewage flow of 30,000,000 gal. per 24 hr., for which the works are designed, the cost will be about $1.85 per capita and about $9240 per 1,000,000 gal. daily.

The works are being built under the direction of the Department of Public Works, Wallace Greenalch, Commissioner, and Frank R. Lanagan, City Engineer. Stephen B. Vernon, Engineer Intercepting Sewer Design and Construction, is in immediate charge of their construction. The works were designed by Hering & Gregory, of New York City, and the contract for their construction was awarded early in July, 1914, to the Riverdale Contracting Co., of New York.

New Coast-Survey Vessel

The contract for the "Surveyor," a new United States Coast and Geodetic Survey vessel, has been awarded to the Manitowoc Shipbuilding and Dry Dock Co., located on Lake Michigan at Manitowoc, Wis. The contract price was $189,000 for the bare hull and machinery, but the ultimate cost of the vessel fully equipped will be $220,000.

The "Surveyor" will be used in surveying and charting the dangerous waters of Alaska and the Bering Sea in the summer and the coasts of Washington, Oregon and California in the winter. She will be a steel steamer of about 1,000 tons displacement, with triple-expansion engines and will use crude oil as fuel. She will accommodate 66 officers and men and carry enough fuel and stores to stay at sea on a surveying cruise for about three months at a time without returning to her base of supplies.

The contract calls for completion within one year, but E. Lester Jones, Superintendent of the United States Coast and Geodetic Survey, has been informed by the contractor that the vessel will be completed in much less time, possibly as early as August, 1916, which will leave ample time to take it to the Atlantic coast before the close of navigation in the Great Lakes.

Concreting Methods and Records, Elephant Butte Dam

By E. H. Baldwin*

SYNOPSIS—Follows article in issue of Sept. 30, 1915, describing masonry work on large Reclamation Service Dam at Elephant Butte, N. M. This article gives details of concreting plant, method of handling concrete and records made in placing concrete.

The masonry of the Elephant Butte dam is concrete, in which large stone is embedded. As concrete was to be the main feature, careful preliminary study was made to design a plant that would be nearly automatic in its operation, require a minimum amount of labor, have large capacity and permit of using as large a percentage of "plum" rock as governing conditions would allow. This point largely decided the use of cableways and derricks for placing the material in the dam rather than the chuting method, though the large amount of excavation to be made and the necessity of storing considerable of it for use as concrete aggregate also had a bearing on the decision in regard to the method to be used.

The concrete-mixing and handling plant was described in detail in *Engineering News*, Aug. 6, 1914, for which reason it will be only briefly outlined here. All concrete is furnished from the main mixing plant near the easterly end of the dam. The materials for the concrete aggregate are delivered to the plant from the main railroad and dumped by gravity to the crushers and sand elevator. The sand and gravel are carried by a separate elevator to the top of the plant, where they are screened, the sand passing into the sand bin, while the gravel is deflected into the bin for broken stone. The rock is crushed and elevated to the top of the plant, where it is screened and distributed to the proper bins, of which there are three—rock, sand and cement. From these the material feeds by gravity through automatic measuring machinery to the mixers.

The mixers are three in number, of the nontilting dump type, with a capacity of 81 cu.ft. each of dry material; but it has been found that a batch of 1.63 cu.yd. of mixed concrete gives the best results. From the mixers the concrete is dumped into hoppers of 3-cu.yd. capacity, from which it is drawn into concrete skips of 3 cu.yd. capacity placed on flat cars, which are drawn by cable and hoist to either of the three cableways spanning the dam. Fig. 2 shows the layout of this part of the plant. The concrete haulage system enables one operator with a 3-drum hoist to deliver the concrete from either mixer to either cableway and return the empty skip to the mixer.

The flat cars are of sufficient length to hold two skips, and are attended by two men, who place the empty skip when lowered by cableway and release the chains. The car is then moved until the loaded skip is directly beneath the cableway; the loaded skip is then hooked up, raised and carried to the dam by cableway and the empty skip returned to mixer for another 3 cu.yd. of concrete. As with the excavation, it was found that the capacity of the plant was generally limited by the cableways, and everything possible was done to increase their efficiency. Time studies were made of the different operations and all false moves eliminated. The same procedure was used on the dam in transferring from loaded to empty skips. The consequence is that the utmost capacity of the cableways has been reached whenever conditions permitted of rapid placing.

*Assistant Chief of Construction, United States Reclamation Service, Denver, Colo.

Handling the Concrete

The concrete is handled on the dam with stiff-leg derricks, of which there are eight in use. The presence of contraction joints in the dam structure has considerably retarded progress. They also have an important bearing on the placing of derricks and the methods used. Below El. 4215 the masonry is monolithic, without joints; but as only a portion of the foundation could be prepared at a time, different blocks began to appear before the entire bottom could be covered, which made the placing of derricks troublesome from the beginning. The derricks are set on pedestals made of concrete blocks manufactured for the purpose. These are 5x6 ft. in plan and 3 ft. high. They are set in mortar and built to a convenient height, usually three blocks or 9 ft. high, but occasionally higher. They are concreted in place as plums and cost very little more than the remainder of the concrete, as they are cast in a special block yard convenient

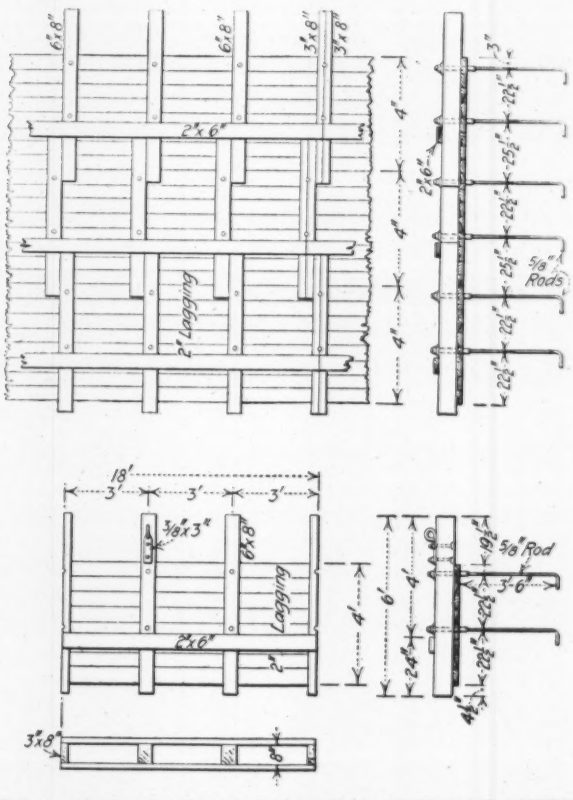


FIG. 1. MOVABLE WOOD FORMS FOR ELEPHANT BUTTE DAM FACE

to the cableways and contain a large percentage of hand rock.

During the early stages of the masonry work it was possible, where the area was quite large, to carry out a program that would permit of raising all derricks on Sunday; but later it was found necessary to move them occasionally during the week, and now that is the general practice. The pedestals are usually prepared by the night shift on prearranged locations and the derricks moved the following morning. This is done by putting slings beneath the sills and engine frame, brought together at the top of the mast, and hooking on to them with two

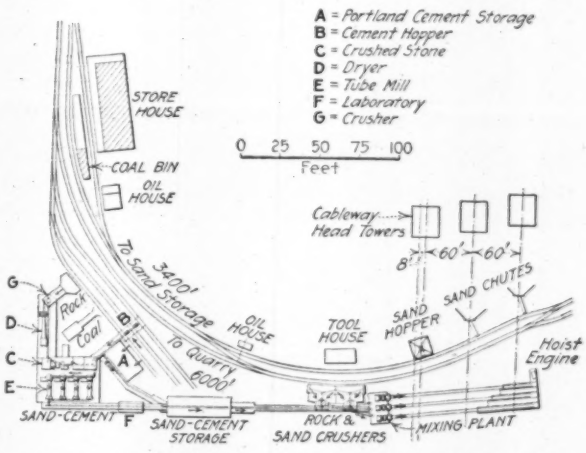


FIG. 2. CEMENT, CRUSHING AND MIXING PLANTS, ELEPHANT BUTTE DAM

cables. A derrick and hoist combined weigh 27 tons, but the change is made in a very few minutes. Ballast blocks are also made of concrete, which facilitates their removal and replacement.

The work on most features in connection with the dam is carried on in three 8-hr. shifts; but the placing of masonry is confined to two shifts, the second and third. On the first shift materials are taken to the dam, repairs to mixing and crushing plants are made and all bins are filled ready for the day's run. The plum rock is loaded on standard-gage flat cars in the quarry, cleaned, washed and side-tracked during the day, then run under cableways at night to be sent down on the first shift. A track scale of 80 tons capacity over which the loaded cars are required to pass enables all stone to be weighed; and as this can be done in a few minutes by the train crew, the custom has been followed from the start. All plum rock and spalls sent to the dam are weighed and recorded, thus giving an excellent measurement of all such material. The plum rock and spalls are placed in convenient piles on the blocks that are to be worked on.

Placing the Concrete

The concrete is delivered on the dam in 3-cu.yd. skips by the cableways, an empty skip is sent back and the loaded skip swung to its place by derrick. The skip is set down for a moment, the front chains released, the skip raised from behind and the concrete flows out. The empty skip is then swung out to the cableway landing and the derrick boom moved out of the way to wait for the next skip of concrete. Four or five men distribute the concrete, spading it against the forms or sides of plum rock, as the case may be. When a layer of sufficient size and thickness has been made plum rock or spalls are embedded in it. As a rule, spalls are only used near forms, between drainage wells or between large rock, as the large plums are cheaper, and a spall improperly placed may spoil a bed for a large stone. As the cableways usually take about 4 min. to make a round trip, and the derricks place a skip of concrete in 2 min., there is generally time to set a stone with the derrick while waiting for the next skip of concrete. This is done by swinging a stone into place and "shaking" it with the derrick. This gives better results than when joggled with a bar, and is much quicker, though rather hard on the derrick.

The organization for each of the two masonry shifts consists of three small placing gangs, one for each cableway, headed by a subforeman. Over these gangs is a foreman in charge of all the masonry work on that shift. In addition to directing these small crews he frequently takes a man or two and sets plums with an extra derrick, and usually has a small cleaning gang to look after in order to keep the working area ready ahead; although the cleaning of any extended area is uniformly done on the first shift. The shifts change each month so that one has no advantage over the other. There is a masonry inspector with each placing gang, one of whom is the chief inspector and has absolute authority in regard to the quality of the work and materials.

There is keen rivalry between the two shifts, and this is fostered by issuing daily bulletins showing the accomplishment of each shift. A system of daily reports that requires every man to be reported by some foreman is in use all over the work. Daily reports showing what they have done are also required from all who are on independent work. In this way a complete and prompt record is obtained of the work performed by every derrick, cableway, locomotive, concrete mixer, crusher, and in fact every machine on the job. These data are assembled in concise manner on printed forms; several copies are made and issued every morning, covering the preceding day's work to those most interested, and are posted in a conspicuous place for the benefit of all.

The placing of masonry as a principal feature did not commence until Mar. 1, 1914, on which date the complete plant was first used. Prior to this time only one cable was used for transporting concrete and plums. The capacity of the plant for mixing and placing concrete was never fully reached. This was due to several unavoidable reasons. Considerable delay in receiving some of the gate and valve castings greatly interfered with the construction programme. Inferior quarries were often responsible for small output, it occasionally being necessary to put the major portion of a quarry force to mucking out the waste. Contraction joint forms and innumerable tunnels, conduits, shafts, gate chambers and drainage wells all tended to curtail output.

Records of Placing

During the twelve months from Mar. 1, 1914, to Mar. 1, 1915, which was the first full year the entire plant was used on masonry work, a total of 380,200 cu.yd. of masonry was placed. With the exception of Kensico Dam in New York State, it is believed that this is the largest quantity ever placed in a single structure in the same period. The best day's run was on Jan. 25, 1915, when 2651 cu.yd. of mass masonry was placed in two 8-hr. shifts. This was made up of 2129 cu.yd. of concrete and

522 cu.yd. of plum rock. The total quantity of masonry placed to Sept. 1, 1915, is 560,000 cu.yd., there being about 610,000 cu.yd. in the completed structure; this leaves 50,000 cu.yd. to place after that date.

As it is not desired to complete the dam during hot weather, and as the working area is rapidly becoming much smaller, especially as every third block is to be left low (El. 4,340) for winter closure, the force was reduced Apr. 1 to such a size as will complete the dam by Feb. 1, 1916. On this account it is probable that the maximum masonry-laying record has already been made.

The flow of the river during early construction was carried in a flume built across the dam and forming a part of it, near the easterly side of the cañon. Early in January of this year, the remainder of the masonry being considered at a safe height, and it being desired to make this closure during cold weather, the flume was closed and the river diverted through the outlets provided in the dam. As these outlets were 20 ft. higher than the bottom of the flume, it was necessary to build up the gap as fast as the water rose in the reservoir. This was successfully accomplished, though at times the water was higher than the concrete, with only leaky forms between. In 29 hr. the concrete was brought up 24 ft., which was sufficient to turn the small quantity of water flowing at the time.

Forms for Concrete

All faces of the dam are cast against forms. The forms for the downstream face and for contraction joints are faced with No. 23 sheet iron, as it is desired that these faces present a smooth finish. Forms for the upstream face are not covered with metal, as a rough finish is desired here in order to get the best obtainable adhesion for the mortar facing. The forms used are the result of careful designing and some experimental work. They have proved very satisfactory, being absolutely self-contained and retaining their true position even with rapid pouring. Fig. 1 shows the details of the principal forms used. Where special forms are required, as around gate wells and offsets, the same principle of fastening and assembling is used, as is shown in the drawings of the simpler type.

Personnel

The construction of the Elephant Butte Dam and auxiliary features is being done by Government forces. From the time the work was commenced until Mar. 1, 1915, it was under the general supervision of L. C. Hill, Consulting Engineer. Prior to October, 1912, H. J. Gault was in direct charge as Construction Engineer. Since that date the work has been under the direction of the writer. L. J. Charles has been principal Assistant Engineer; R. J. Schmalhausen, Superintendent of Construction; R. R. Coghlan, Manufacturing Cement Chemist; W. C. Beatty, Master Mechanic, and Walter Cowell, Chief Masonry Inspector. Since Mar. 1, L. J. Charles has been Construction Engineer under the general supervision of the writer.

It is manifestly impossible to give here individual credit to all who are responsible for the excellent results obtained, as the results accomplished are due to an organization in which every employee of any responsibility whatever rendered loyal and efficient service with the idea of building the dam in the best manner in the quickest time, and at a minimum cost.

Submarines and Torpedoes*

By C. N. Hinkamp†

Interest in the submarine has reached a point hardly dreamed of five years ago. The types developed by the American inventors Holland and Lake have now been adopted as practically the standards of the world. Holland's experiments began in 1875, but it was not until 1893 that his plans were approved by the American Naval authorities. In 1904 Lake's boats were built for Russia.

Up to 1898 the submarine was in the embryonic state. From then up to the present time it has developed rapidly.

There is nothing mysterious in the operation of a submarine. The orders used in the handling of a boat are few and are so given as to eliminate any possible confusion. Preparing to submerge includes all preliminary work up to the closing of the conning-tower hatch. This comprises the stowing of the deck gear, taking down the bridge, unrigging the radio, closing the hatches, unlocking the valve-operating mechanism, securing the engines—in fact, a clearing ship for action. This operation requires from two to twenty minutes, depending on the amount of rigging to be taken down.

In the static dive, also known as "balancing," the boat is submerged but moves only in the vertical plane.

The mass of the submarine itself amounts to several hundred tons, but the actual forces used to sink it from a neutral state are very small. The addition of 50 lb. of water will cause the boat slowly to descend. As soon as the vessel has started on its downward path it is necessary to remove part of the ballast in order to keep it from continuing on this path.

The running dive is made from the awash condition. In the awash condition the trimming tanks and auxiliary ballast tanks are flooded to the amount necessary for the proper trim when submerged; the main ballast tanks are empty. The running dive is used for all tactical purposes except balancing.

The vessel being underway "awash," the order is given to submerge. All hands get into the boat, the engines are stopped and the electric motors started. As soon as the engines are stopped the conning tower is closed, all ventilators are housed and the main ballast tank is flooded. Knowledge that the trim will be approximately correct when totally submerged renders careful adjusting of ballast unnecessary. The boat is inclined slightly, about one-half of a degree down by the head, and the inrush of the water is controlled by manipulation of the valves. All this is done in the short period of from one to two minutes.

Submerging a submarine is distinctly a one-man job. The commanding officer must be thoroughly conversant with all the details of the actual submerging of the boat and he must at all times be thoroughly informed as to existing conditions in the boat. The second officer assigned to the submarine generally assists the commanding officer where possible, and endeavors to acquire all the information possible on the details of the operation in order that he may take charge in case of any emergency.

Depth is maintained by the use of the diving rudders. Down rudder sends the stern up and the bow down. As soon as the boat is inclined downward the plane of the

*Extracts from a paper in the "Journal" of the American Society of Naval Engineers.

†Lieutenant, United States Navy.

deck gives a large surface for the water to act on. The hull is so built that normally there is a tendency for the boat to rise, brought about by the angle of the hull and the unbalanced pressures caused by inequalities in the areas of the surfaces on the bottom of the boat and on the top of the boat. This tendency must be counteracted by the trimming of the vessel and the action of the diving rudders.

The steering of the vessel in azimuth is done the same submerged as on the surface, using either hand or electric power. The use of gyroscopic compasses renders the tactical problems far simpler, as it is possible with this compass to steer the vessel within narrower limits than was possible with the magnetic compasses.

The periscopes are the eyes of the submarine. There are many styles of periscopes—monocular, binocular, stationary, revolving, rotating eyepiece, stationary eyepiece and "walk around." There are also devices known as omniscopes, in which the entire horizon is reflected on a ground glass and any part can be separated from the rest by means of screen sectors. The periscopes are long tubes with lenses in the top and bottom and so fitted with prisms that the rays of light are paralleled. The general impression one gets is that of looking through a telescope.

The periscope that is in most general use in the United States Navy is the walk-around type, with normal and magnifying eyepieces. Each boat is required to have at least two periscopes, one for the commanding officer and one for the helmsman or the second officer. In the recent boats, fitted with gyroscopic compasses, the helmsman takes his station at the compass while the lookout is at the periscope from which he directs the helmsman. The commanding officer usually stations himself at the after periscope and directs the movements of the vessel. Should he leave the periscope for any purpose, such as to consult chart or to get signals, some one always takes his place, so that there is never a time that both periscopes are not manned.

Signaling while submerged is a subject of much interest. In the early days of submarine navigation signaling under water was done in a most crude manner, for which the hull of a vessel was found to be peculiarly adapted. Sending was accomplished by tapping on a rivet with a hammer and receiving by holding the forehead to a frame of the boat. For several years inventors have investigated and experimented extensively, with the result that there are now in practical use in submarine signaling the submarine bell, the Fessenden oscillator and the vibrating wire, by which it is possible to signal effectively at distances greater than 5 mi. under favorable conditions. All these systems set up vibrations in the water which are detected by microphones and heard through the ordinary telephone receiver.

Each submarine is equipped with one bell, some with two, and on every submerged run, in peaceful maneuvers, these bells are rung so that it is possible for those in one boat to know the approximate location of other boats.

The submarine of the present day can operate at its maximum speed submerged for about 1 hr. At about one-third of this maximum speed she can operate practically 24 hr.

The offensive weapon of the submarine is the torpedo, or if necessity demands, the vessel itself can be used as a ram. The effect of the submarine as a ram may be illustrated by the fact that in a collision between a United States submarine and its tender several years ago, the tender was so badly damaged as to require beaching in order to save her.

The principal offensive weapon is, however, the torpedo. Ramming would be resorted to only in an exceptional case. The torpedo is an intricate mechanism built along the lines of the submarine itself, but automatic in its action after leaving the tube from which it is fired. The torpedo is divided into four main parts—the head, air flask, afterbody and tail. The head contains the explosive and the mechanisms to fire it. These heads are carried on the torpodeos only in war time. In time of peace exercise heads containing water are used. Abaft the head is the air flask. This contains the compressed air for the propelling machinery. In the next division of the torpedo is found the depth-controlling mechanism, the air superheater, the main propelling engines, the steering engines and gyroscope, and the shafting to the propellers, as well as the rods to the rudders. The tail inside contains the gear wheels for the propellers; on the outside are the supporting parts for the propellers, the diving rudders and the vertical rudders. The early torpedoes had an effective range of about 500 yd. The most modern product has an effective range of more than 10,000 yd.

An attack on a hostile vessel can be made in so many ways, and would have to be made under so many different conditions, that it is impossible to lay down any hard and fast method of procedure. The best time to attack is at dawn or twilight, or at a time when there is enough sea running to make the detection of the presence of the boat most difficult. Submarines have been known to approach within 500 yd. of a battleship in a choppy sea and in a fog to come up under the stern before being discovered, notwithstanding the fact that lookouts were stationed on the battleships to watch for the submarines.

The best situation for an attacking submarine is forward of the enemy's beam and approaching her. From such a position it is possible to get within range most easily and lie in wait until the enemy crosses the path of the submarine. In such a case it is possible for the submarine to pick the time for firing with some degree of assurance that the torpedo will reach the enemy and destroy her. Should the enemy be very much faster than the submarine, tactics become a case of hare and hound, with the advantage in favor of the enemy, as the speed of a submarine is limited.

The subject of safety in the submarine has received much attention and many devices have been invented designed to obviate the dangers said to attend the operation of this type of vessel. Each designer and builder has his own method of escape.

As submarine design improves, dangers of operation are becoming fewer. Today the submarine possesses no more inherently dangerous features than are possessed by any ship. In fact, they are safer to cruise in than a surface craft and for the same tonnage are far more comfortable in a heavy sea.

The personnel of a submarine depend for air for breathing purposes while submerged on the free air in the boat at the time of submerging and the compressed air carried in storage flasks, which is used in freeing ballast tanks of water as well as for breathing. In the average submarine in commission today the air contained in the boat at the time of submerging is sufficient to last officers and crew, numbering 18 men, for a period of from 9 to 12 hr.

Field and Office

New York Tunnel Power Plants

Two large plants have been erected by the Flinn-O'Rourke Co., on the Manhattan and Brooklyn sides of the East River, New York City, for supplying compressed air and high-pressure water to 12 shields in the four rapid-transit tunnels being driven by this company. These stations are of particular interest because of the large aggregate capacity of air compressors installed (in accordance with the requirements of the Public Service Commission, under whose direction the tunnels were planned and are being built) and because of the types of equipment assembled.

These plants must meet heavy requirements as to continuity of service and reliability. They are therefore examples of first-class practice, within the limits imposed by space conditions.

The plant on the Brooklyn side has, roughly, twice the capacity of the Manhattan station, since eight shields are being driven on this side and only four in Manhattan. It is seen from Fig. 2 that there are eight large compressors for the main air supply. These are of the latest duplex motor-driven type built by the Ingersoll-Rand Co. and equipped with thin plate valves (Rogler type), which have found extensive and successful use in Europe. Each unit has a delivery capacity at 166.6 r.p.m. of 4900 cu.ft. (free air) at 15 lb. per sq.in. and it then requires 350 electrical horsepower. The machines will deliver air at up to 45 lb. pressure and for such possible service the motors used are of 600-hp. rating. The motors are

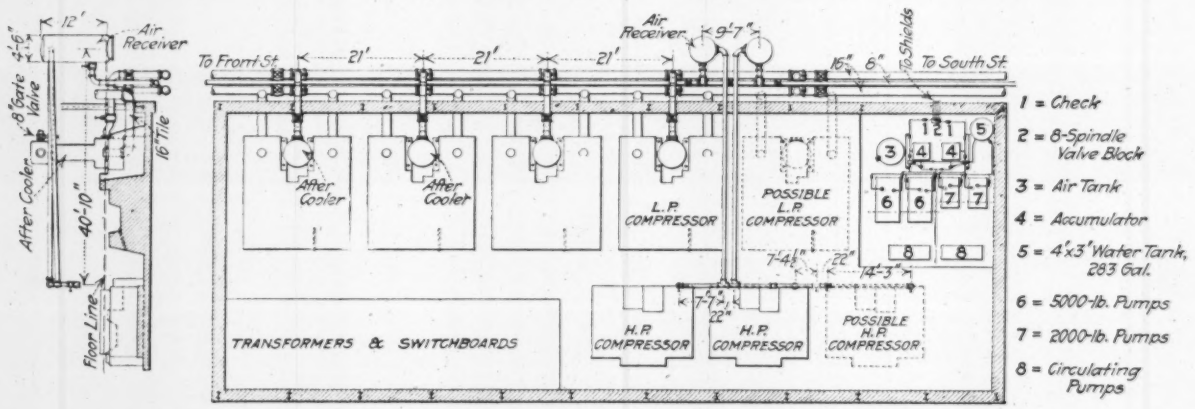


FIG. 1. GENERAL PLAN AND AIR PIPING; MANHATTAN TUNNELS POWER PLANT

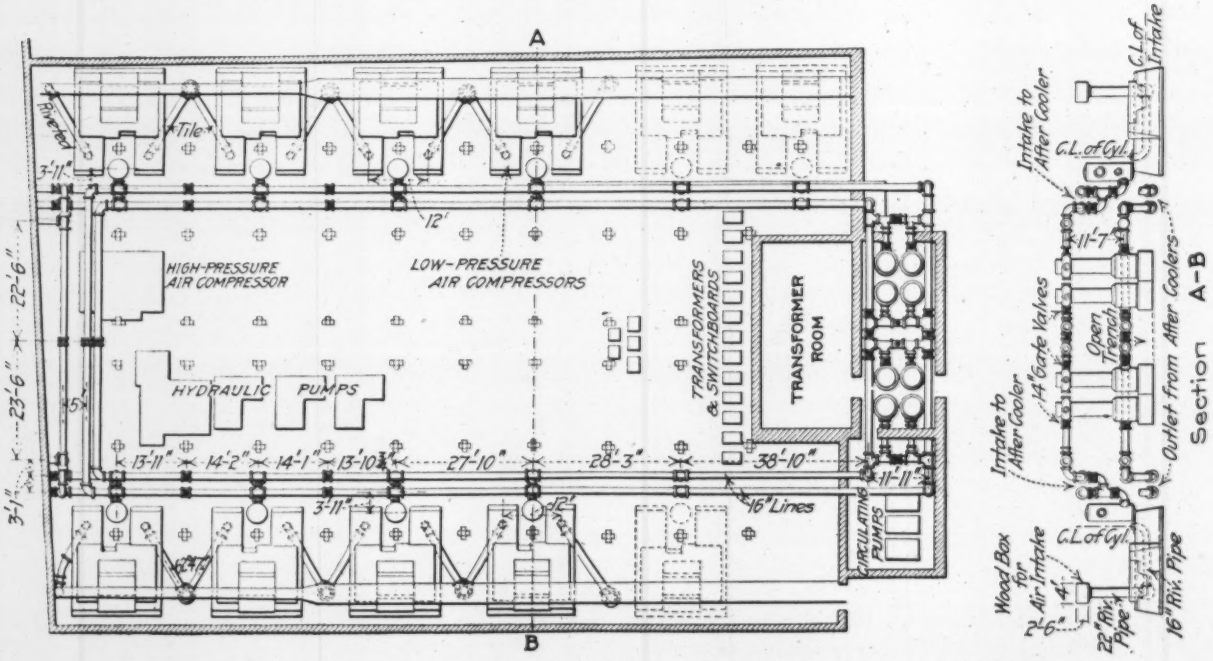


FIG. 2. PLAN OF MACHINES AND PIPING; BROOKLYN POWER PLANT, FLINN-O'ROURKE CO.

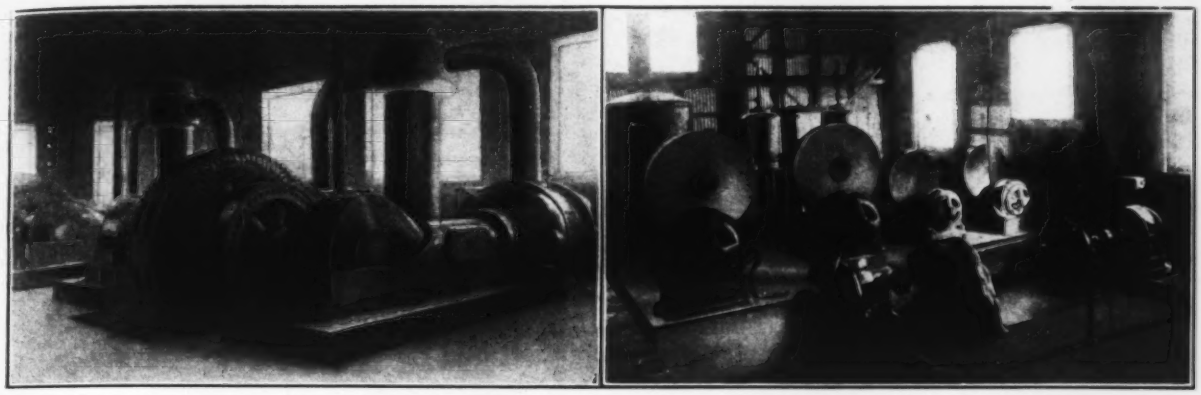


FIG. 3. LOW-PRESSURE AIR COMPRESSOR AND HIGH-PRESSURE PUMPS, FLINN-O'ROURKE MANHATTAN STATION

of 6600-volt three-phase synchronous type with individual belted exciters; they start as induction motors. Power is secured at 6,600 volts from the local Edison company, direct feeders running to the nearest substation.

Because of lack of room in this plant (it being the basement floor of an old warehouse and having heavy wooden columns about 14 ft. apart) the aftercoolers have been grouped at one end of the building, as shown in Fig. 2. The air-piping layout is also seen from this sketch.

For the tunnel-shield jacks and erector there are a 5000-lb. pump of 25 gal. per min. capacity and a 2000-lb. pump good for 15 gal. per min. Both are motor-driven and connected to accumulators. Besides this there are three 75-hp. motor-driven high-pressure plunger pumps for miscellaneous service.

In the Brooklyn plant there is one compressor for supplying high-pressure air (140 lb.) for tools in the tunnels. This is an old 20x14x18-in. Sullivan compound machine driven by a 400-hp. synchronous motor.

Equipment of the Manhattan Station

In the Manhattan plant there are four of the new 28x24-in. duplex low-pressure air compressors such as are installed in the Brooklyn plant. The aftercoolers, however, are placed in their usual position close to the machines. There was plenty of room in this plant, as a large steel building (with concrete floors) was erected in Jeannette Park. Half of it was given over to forge shops and stores and half to the power station.

The high-pressure air for tools, etc., is supplied by two old Sullivan compound machines—a 26x15½x18-in. for 100 lb. and a 25x14x16-in. for 135 lb. Each is driven by a 400-hp. synchronous motor.

The arrangement for the high-pressure hydraulic service is shown by Fig. 1. The 15-gal. 5,000-lb. and 10-gal 2000-lb. pump are in duplicate. The suction comes from an open tank, and the discharge is fed to the accumulators. For each system there is an automatic controller that lets the water be spilled back into the storage tank when the accumulators are full, a pump running continuously during the interval in which water is needed for the jacks or rams in a shield. A valve block, similar to those used on the tunnel shields, distributes either 5000- or 2000-lb. pressure to one or more main lines of 1½-in. XX pipe running to and down each shaft. A similar design is employed in the Brooklyn plant.

Moving Brick by Wheelbarrow

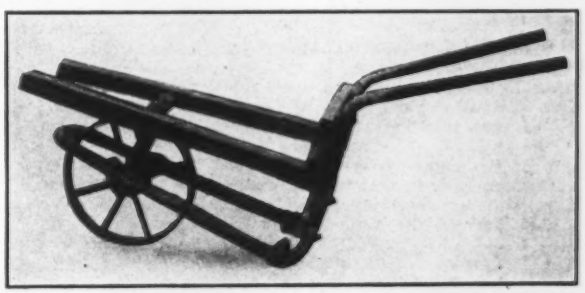
By W. B. Conant*

A specially designed wheelbarrow has been found very satisfactory for handling brick and other building materials by hand. It is constructed of a bent steel frame that encircles the wheel axles with handles of one piece with the frame. From the handles forward over the wheel is a stout wooden rack 24 in. wide at the back and tapering toward the front, where the joists are 7½ in. apart.

Three 18-brick trays are usually carried at a load. It has been found that 150 ft. is about the maximum distance over which brick can be economically transported by wheelbarrow. In all cases a smooth plank runway should be provided. For greater distances, industrial-railway or wagon haulage is more economical.

A recent test showed that three trays (54 bricks) could be wheeled 150 ft. and delivered to an elevator and the wheelbarrow returned, in 2 min. Increasing the distance to 200 ft. lengthened the time of the round trip to 3 min.

In wheeling bricks to an elevator the loaded wheelbarrow is left to be cared for by a man stationed to transfer the trays to the elevator, and the laborer re-



SPECIAL WHEELBARROW USED BY ABERTHAW CONSTRUCTION CO. FOR HANDLING BRICK

turns with an empty wheelbarrow to the storage pile or car. Two men can supply the material for 19 masons provided the bricks are within 150 ft. and the mortar within 100 ft. of the elevator.

The wheelbarrow men should be under orders of the man at the base of the elevator or hoist, who directs the delivery of either mortar or brick as required on the

*Concord, Mass.,

scaffold. There the boxes of mortar and trays are transferred by wheelbarrows three at a time to the bricklayers.

Doctoring Test-Pieces for Steel of Panama Lock Gates

The necessity for great vigilance and ingenuity on the part of mill inspectors was demonstrated in a peculiar way in an action recently brought by the United States Government against certain officers and employees of the Carbon Steel Co. for conspiracy to furnish defective steel for the Panama lock gates. When the case was tried in the United States District Court at Pittsburgh, some of the defendants were found guilty.

Test-pieces from nickel-steel forgings were annealed surreptitiously in the blacksmith shop to give them just the right qualities for passing the specifications, although the annealed forgings did not have these qualities. The inspectors at first were in the habit of marking the steel slabs before annealing, the marked pieces being cut off and annealed in the furnace with the slab, test being made on the test-pieces after coming from the furnace. It was discovered, however, that some of the steel was not annealed, but was merely "smoked"; that is, put through the furnace at a low heat to discolor it just enough so that it would appear to have been annealed, while in reality having the qualities resulting from heating and quenching. The men in charge of the work for the company would take test-pieces and privately subject these to quenching and drawing tests until they had found just what heat-treatment would bring the test-piece within specifications. Thereupon the government test-piece would be put through the heat-treatment so determined.

The peculiar appearance of one or two of the test-pieces, resulting from the special treatment they were subjected to, aroused the inspectors' suspicion. Going into the plant when not expected, an inspector found one of the defendants standing at a furnace in which were some test-pieces. The latter explained that he was making private tests of his own and refused to show the pieces, but the inspector on pulling them out of the furnace found that they were his selected test-pieces bearing his stamp.

Loading Excavated Material from a street subway across the Illinois Central R.R. at Chicago was accomplished in a novel manner. The tracks were supported on a pile trestle. The excavation was done by hand, and the material was loaded into small steel dump cars on a narrow-gage track at the street level. These cars were pushed by hand to one side of the right-of-way and dumped into a large elevator bucket working in a tower built alongside the nearest track. A railway car was placed on this track, and the elevator bucket dumped the material into it.

Reducing Decimals of an Acre to Square Feet

A very handy table which gives the equivalent of any decimal of an acre (in thousandths) in square feet directly, without interpolation, is sent to *Engineering News* by C. H. Eiffert, Assistant Engineer, Windes & Marsh, Engineers-Contractors, Winnetka, Ill. This table forms a useful supplement to the table for reducing square feet to decimals of an acre in *Engineering News*, Aug. 19, 1915, p. 363.

DECIMALS OF ACRES IN SQUARE FEET

	0.000	0.001	0.002	0.003	0.004	0.005	0.006	0.007	0.008	0.009
0.00		44	87	131	174	218	261	305	348	392
0.01	436	479	523	566	610	653	697	741	784	827
0.02	871	915	958	1002	1045	1088	1132	1176	1219	1263
0.03	1307	1351	1394	1438	1482	1525	1569	1612	1656	1699
0.04	1742	1786	1829	1873	1916	1960	2003	2047	2090	2134
0.05	2178	2222	2265	2309	2352	2396	2439	2483	2526	2570
0.06	2614	2658	2701	2745	2788	2832	2875	2919	2962	3006
0.07	3049	3093	3136	3180	3223	3267	3310	3353	3397	3441
0.08	3485	3529	3572	3616	3659	3703	3746	3790	3833	3877
0.09	3920	3964	4007	4051	4094	4138	4181	4225	4268	4312
0.10	4356	4400	4443	4487	4530	4574	4617	4661	4704	4748
0.11	4792	4836	4879	4923	4966	5010	5053	5079	5140	5184
0.12	5227	5271	5314	5358	5401	5445	5488	5532	5575	5619
0.13	5663	5707	5750	5794	5837	5881	5924	5968	6011	6055
0.14	6098	6142	6185	6229	6272	6316	6359	6403	6446	6490
0.15	6534	6578	6621	6665	6708	6752	6795	6839	6882	6926
0.16	6970	7014	7057	7101	7144	7188	7231	7275	7318	7362
0.17	7405	7449	7492	7536	7579	7623	7666	7710	7753	7797
0.18	7841	7885	7928	7972	8015	8059	8102	8146	8189	8233
0.19	8276	8320	8363	8407	8450	8494	8537	8581	8624	8668
0.20	8712	8756	8799	8843	8886	8930	8973	9017	9060	9104
0.21	9148	9192	9235	9279	9322	9366	9409	9453	9496	9540
0.22	9583	9627	9670	9714	9757	9801	9844	9888	9931	9975
0.23	10019	10063	10106	10150	10193	10237	10280	10324	10367	10411
0.24	10454	10498	10541	10585	10628	10672	10715	10759	10802	10846
0.25	10890	10934	10977	11021	11064	11108	11151	11195	11238	11282
0.26	11326	11370	11413	11457	11500	11544	11587	11631	11674	11718
0.27	11761	11805	11848	11892	11935	11979	12022	12066	12109	12153
0.28	12197	12241	12284	12328	12371	12415	12458	12502	12545	12589
0.29	12632	12676	12719	12763	12806	12850	12893	12937	12980	13024
0.30	13068	13112	13155	13199	13242	13286	13329	13373	13416	13460
0.31	13504	13548	13591	13635	13678	13722	13765	13809	13852	13896
0.32	13939	13983	14026	14070	14113	14157	14200	14244	14287	14331
0.33	14375	14419	14462	14506	14549	14593	14636	14680	14723	14767
0.34	14810	14854	14897	14941	14984	15028	15071	15115	15158	15202
0.35	15246	15290	15333	15377	15420	15464	15507	15551	15594	15638
0.36	15682	15726	15769	15813	15856	15900	15943	15987	16030	16074
0.37	16117	16161	16204	16248	16291	16335	16378	16422	16465	16509
0.38	16553	16597	16640	16684	16727	16771	16814	16858	16901	16945
0.39	16988	17032	17075	17119	17162	17206	17249	17293	17336	17380
0.40	17424	17468	17511	17555	17598	17642	17685	17729	17772	17816
0.41	17860	17904	17947	17991	18034	18078	18121	18165	18208	18252
0.42	18295	18339	18382	18426	18469	18513	18556	18600	18643	18687
0.43	18731	18775	18818	18862	18905	18949	18992	19036	19079	19123
0.44	19166	19210	19253	19297	19340	19384	19427	19471	19514	19558
0.45	19602	19646	19689	19733	19776	19820	19863	19907	19950	19994
0.46	20038	20082	20125	20169	20212	20256	20299	20343	20386	20430
0.47	20473	20517	20560	20604	20647	20691	20734	20778	20821	20865
0.48	20909	20953	20996	21040	21083	21127	21170	21214	21257	21301
0.49	21344	21388	21431	21475	21518	21562	21605	21649	21692	21736

DECIMALS OF ACRES IN SQUARE FEET

	0.000	0.001	0.002	0.003	0.004	0.005	0.006	0.007	0.008	0.009
0.50	21779	21823	21866	21910	21953	21997	22040	22084	22127	22172
0.51	22215	22259	22302	22346	22389	22433	22476	22520	22563	22607
0.52	22651	22694	22738	22781	22825	22868	22912	22955	22999	23043
0.53	23087	23130	23174	23217	23261	23304	23348	23391	23435	23478
0.54	23522	23565	23609	23652	23696	23739	23783	23826	23870	23914
0.55	23957	24001	24044	24088	24131	24175	24218	24262	24305	24350
0.56	24393	24437	24480	24524	24567	24611	24654	24698	24741	24785
0.57	24829	24872	24916	24959	25003	25046	25090	25133	25177	25221
0.58	25264	25307	25351	25394	25438	25481	25525	25568	25612	25656
0.59	25700	25743	25787	25830	25874	25917	25961	26004	26048	26092
0.60	26136	26179	26223	26266	26310	26353	26397	26440	26484	26528
0.61	26571	26614	26658	26701	26745	26787	26831	26874	26918	26963
0.62	27007	27050	27094	27137	27181	27224	27268	27311	27355	27399
0.63	27442	27486	27529	27573	27616	27660	27703	27747	27791	27834
0.64	27878	27921	27965	28008	28052	28095	28139	28182	28226	28270
0.65	28314	28357	28401	28444	28488	28531	28575	28618	28662	28706
0.66	28749	28793	28836	28880	28923	28967	29010	29054	29097	29141
0.67	29185	29228	29272	29315	29359	29402	29446	29489	29533	29577
0.68	29620	29664	29707	29751	29794	29838	29881	29925	29968	30012
0.69	30056	30100	30143	30187	30230	30274	30317	30361	30404	30448
0.70	30492	30535	30579	30622	30666	30709	30753	30796	30840	30884
0.71	30927	30971	31014	31058	31101	31145	31188	31232	31275	31319
0.72	31363	31406	31450	31493	31537	31580	31624	31667	31711	31755
0.73	31798	31842	31885	31929	31972	32016	32059	32103	32146	32190
0.74	32234	32277	32321	32364	32408	32451	32495	32538	32582	32626
0.75	32670	32713	32757	32800	32844	32887	32931	32974	33018	33062
0.76	33105	33149	33192	33236	33279	33323	33366	33410	33453	33497
0.77	33541	33584	33628	33671	33715	33758	33802	33845	33889	33933
0.78	33976	34019	34063	34106	34150	34193	34237	34280	34325	34368
0.79	34412	34455	34499	34542	34586	34629	34673	34716	34760	34803
0.80	34847	34891	34936	34980	35023	35067	35110	35154	35197	35240
0.81	35284	35327	35371	35414	35458	35501	35545	35588	35632	35676
0.82	35719	35763	35806	35850	35893	35937	35980	36024	36067	36111
0.83	36155	36198	36242	36285	36329	36372	36416	36459	36503	36547
0.84	36590	36634	36677	36721	36764	36808	36851	36894	36938	36982
0.85	37026	37069	37113	37156	37200	37244	37287	37331	37374	37418
0.86	37462	37505	37549	37592	37636	37680	37724	37767	37811	37854
0.87	37898	37941	37985	38029	38072	38116	38159	38203	38246	38289
0.88	38332	38376	38419	38463	38506	38550	38593	38637	38680	38725
0.89	38769	38812	38856	38899	38943	38986	39030	39073	39117	39160
0.90	39204	39247	39291	39334	39378	39421	39465	39508	39552	39596
0.91	39639	39682	39726	39770	39812	39856	39901	39945	39987	40032
0.92	40076	40119	40163	40206	40249	40293	40336	40380	40423	40467
0.93	40511	40554	40598	40641	40685	40728	40772	40815	40859	40903
0.94	40947	40990	41034	41077	41121	41164	41208	41251	41295	41338
0.95	41382	41425	41469	41512	41556	41599	41643	41686	41730	41774
0.96	41818	41861	41905	41948	41992	42035	42079	42122	42166	42210
0.97	42254	42297	42341	42384	42428	42471	42515	42558	42602	42645
0.98	42689	42732	42776	42819	42863	42907	42950	42994	43037	43081
0.99	43125	43168	43211	43255	43298	43342	43385	43429	43472	43516

Multiplying Large Numbers on Adding Machines

By R. C. Hardman*

In many offices where engineers are employed adding machines form part of the equipment, but generally their use is not thoroughly understood. The simple operations of adding and subtracting and of performing the multiplication of small numbers are familiar, but few even know that multiplication of numbers of seven or eight places may be made. However, such numbers, although their product will be far beyond the capacity of the adding machine to record, can be easily and rapidly multiplied. With a little practice, a great saving of time can be effected. This is especially true of the 10-key machines. The 81-key types are not nearly so efficient.

For example, multiply 29,476,392 by 41,242,342, which is equivalent to the multiplication of two trigonometric functions carried to seven decimal places. In order to perform this operation on the machine, we first divide the numbers mentally as follows:

$$(A)\ 2947 \quad 6392\ (B)$$
$$(C)\ 4124 \quad 2342\ (D)$$

This is equivalent to multiplying $(10{,}000A + B)$ by $(10{,}000C + D)$, or,

$$\begin{array}{r} 10{,}000\,A + B \\ 10{,}000\,C + D \\ \hline BD + 10{,}000\,(AD + BC) + 100{,}000{,}000\,AC \end{array}$$

Substituting the values of A, B, C and D we have:

$$\begin{array}{rr} BD = & 14970064 \\ 10{,}000\,(AD + BC) = & 332624820000 \\ 100{,}000{,}000\,AC = & 12153428000000000 \\ \hline & 12156754397900 64 \text{ (product)} \end{array}$$

On the machine we do exactly the same thing, the printed slips issuing thus:

BD	$AD + BC + 1497$	$AC + 3326$
6392	1497	3326
6392	2947	2947
63920	2947	2947
63920	29470	2947
63920	29470	2947
63920	29470	29470
639200	29470	29470
639200	294700	294700
639200	294700	2947000
6392000	294700	2947000
6392000	2947000	2947000
14970064	2947000	2947000
	6392	*12156754*
	6392	
	6392	
	6392	
	63920	
	63920	
	639200	
	6392000	
	6392000	
	6392000	
	6392000	
	33263979	

*Colorado Springs, Colo.

The product is 12156754 3979 0064. It will readily be seen why the 1497 is carried from the first total and added to the second operation, and 3326 from the second total added to the third, after an inspection of the product found by the substitution of values in the algebraic function above.

Practically speaking, the multiplication of eight-place numbers is the limit of a nine-place adding machine, as the single product of four-place B and D makes an eight-place result. However, the divisions A, B, C and D might be further subdivided indefinitely and the same process gone through. This would be too complicated to be of any value, although 16- or 32-place numbers could be multiplied. Thus, 16-place numbers would be divided:

$$\begin{array}{cc} a\ b & e\ f \\ A & B \\ c\ d & g\ h \\ \\ i\ k & n\ o \\ C & D \\ l\ m & p\ q \end{array}$$

It will readily be seen that the great amount of cross multiplying would prove unwieldy.

Laying 48-In. Concrete Block Sewer

A 48-in. concrete-block sewer using the Parmley type of block is being constructed in Harrisburg, Penn., by M. M. Sheesley & Sons, of Johnstown. The total length is about 1500 ft. Most of it is in a trench 5 to 12 ft. deep and follows normal construction methods except that the soil is all filled ground, which produces some complications. A short length of the sewer, however, is 3 to 5 ft. above ground, at the bottom of a depression remaining as the last portion of a partly filled gully. Here the sewer is built on three-post bents 5 ft. 4 in. wide out to out and 5 ft. apart. The invert blocks are bedded on a thin layer of concrete placed on longitudinal timbers laid over the bent caps. Concrete fill under the haunches and extending up to the middle line of the pipe, with a thickness of 4 in. at this line, braces and retains the sewer.

The blocks were made on the ground by the contractor's men. There are four blocks per ring, and each ring is 12 in. long. Metal forms with removable pieces to give the changes for the bottom, side and top blocks were employed. With two forms and an unlimited supply of wooden baseboards, or pallets, fitted with a curve strip to make the groove of the ring joint, a gang of nine men was kept busy. The best day's work was 225 blocks (10 hr.) The same contractors, however, were able to make 250 blocks with eight men on a similar job in Johnstown some months ago. The concrete is mixed rather dry and is tamped hard into the form and leveled off on top, the form then being immediately stripped to use again.

The sewer trench is excavated by clamshell handled by a Marion-Osgood locomotive crane. In the deeper portion, on account of the tendency of the sides to cave, only 20 ft. or so is kept open ahead of the sewer laying, and some bracing is used. The bottom is trimmed by hand. Where the ground is bad two boards are laid down on the line of the pipe to proper bottom level, and the space between and alongside them is leveled up with

concrete. Then the flat-bottomed lower section of the sewer is set on this cradle with a 2-in. strip of tar paper under the joint, long enough to come up along the side section. Concrete filling is then placed under the haunches. The sides of the trench, if it is too narrow, are trimmed to template to enable the side sections to be placed, and these are set in mortar beds after placing dowel rods in the longitudinal joints and a ring rod in the circular joint. Using a diameter gage to get the correct position for the upper corners of the side blocks, they are braced from the sides of the trench. Finally the key block is set.

Striking off and pointing the joints inside and outside finishes the upper half of the sewer. The lower half joints of the side blocks, however, are not filled with mortar when the blocks are set, but are left to be grouted afterward, the tar-paper strip being the form, or cover, for this grouting. Backfill is placed at the sides of the pipe up to the middle line and tamped with a board or other rammer, according to the width of the space to give the sewer solid side support and at the same time fix the tar-paper strip in place. Grout is then poured into the ring joint to fill, completing the work.

The speed of laying blocks on this work has been limited in most cases by the trench work, but on one or two occasions there was a chance to lay sewer at maximum rate. One mason and helper laid 74 lin.ft. of invert block in an 8-hour day, and at the same time 51 lin.ft. of side and top blocks were set by another man and helper.

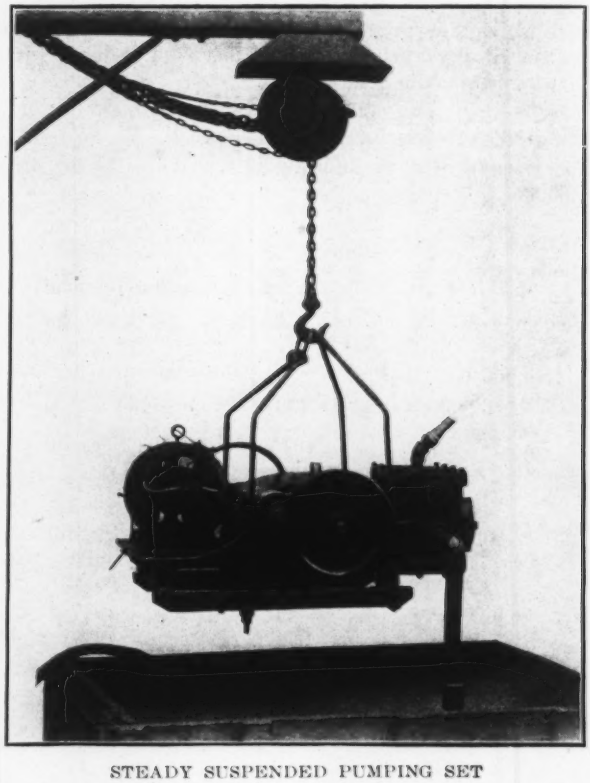
NOTES

Limestone as a Concrete Aggregate—A county highway commissioner of Wisconsin has objected to the use of crushed limestone as coarse aggregate in concrete-road construction. He based his objections on two points—first, that limestone is softer than gravel; and second, that the dust which adhered to the limestone interferes with its bonding in the concrete. Conceding that there is reason for the first objection where the limestone has a French coëfficient of less than 12 and a hardness of less than 10, it still seems that the second point is rather far-fetched. Where machine mixing is used, it would seem that the slight dust coat would be washed or rubbed off into the fine aggregate, causing there no greater harm than the relatively greater volume of inert material often added for waterproofing purposes. If that objection were generally held, it would seriously interfere with the use of limestone for concrete purposes in localities where it is the most economical material. The experience of some of your readers would be of great interest.—George F. Prussing, Lennon, Wis.

Rapid Work in Road Surveying—The survey of a 5½-mi. stretch of country road was made by me recently in two days, using a one-horse team and driver and an inexperienced rodman. The actual time spent in surveying was about 6½ hr. per day. All angles were turned twice with a transit and the distances measured with a 100-ft. steel tape. All prominent topographical features were noted. The shots averaged 1,400 ft. in length. The method of working was as follows: The instrumentman, with the rodman in the buggy with him, would drive ahead and choose the location for the hub. The rodman would set the hub and tack and remain to give the forward sight. The angle was then turned, and both rodman and driver returned to the instrument point. The driver then took the transit in the buggy and carried it to the point ahead. The rodman and instrumentman chained the distance to the point ahead. The process was then repeated for the next point. The actual cost of the survey, figuring the instrumentman at $5 per day, rodman at $1.50, team and driver at $2, was $17.—T. J. Wright, Jr., Engineer-in-Charge, Board of Water Commissioners, Portsmouth, Va.

A Fire Engine Has Been Commandeered to furnish a water jet to break up some refractory material being excavated in the new deep-water terminal work at Halifax, Nova Scotia. The corner of one of the quay walls is being laid inside of a coffer-dam made up of sheet piles with hardly any penetration in the hard cemented rock bottom, which resisted the attack of the clamshell with which the excavation was attempted. The coffer-dam was of so temporary a nature as to preclude the possibility of blasting within it, so as a solution of the difficulty a local fire engine was brought to the site and using a 1-in. nozzle on a 3-in. hose, a jet was forced down into the bottom under a pressure of 150 lb. This jet has broken up the formation, or at least loosened the cemented areas between the rock to such an extent that clamshell work has been made possible. It is stated by the engineers on the work that while this jetting is not remarkably good and possibly would not be used for similar future work, still in this particular case it does loosen the material so that the work can be carried on, and therefore will have overcome what at least promised to be a temporary difficulty.

A Remarkably Steady Pumping Set—The accompanying view shows a motor-driven triplex pump set suspended over a supply tank. The steadiness of the outfit and the freedom from vibration is shown by a 5-in. wire nail placed upright on the motor base. The pump is a 3x3-in. double-acting Luitwieler type pumping 82 gal. per min. at 150 r.p.m. Each piston is thrown by a cam working between roller guides,



STEADY SUSPENDED PUMPING SET

the cam outline and spacing being designed to secure uniform water pressure and flow and perfect balance of moving parts. The working parts of the pump are incased and given splash lubrication. The total weight of the unit shown is 1,385 lb., including that of the 3-hp. 1,600-r.p.m. motor. The nozzle has a 1⅛-in. opening and is spouting under 50 lb. per sq.in. pressure.

Rounded Pier Nosings were required on the piers of the Cumberland Valley R.R.'s new bridge over the Susquehanna River at Harrisburg, Penn., by the State Water-Supply Commission. The old piers had V-shaped nosings on the upstream cutwaters and square ends downstream. Considerable deposit had accumulated in the river bed some distance downstream of each pier. The new bridge having twice as many piers and the old piers being thickened, a reduction of waterway (at extreme flood) of about 8% was produced. With a view to making the waterway as efficient as possible for the flow, the Water-Supply Commission engineers required the use of circular or elliptic nosings at upstream and downstream ends of the piers, in order to reduce the disturbance and eddying caused by the piers, and largely prevent the formation of deposits below them.

Editorials

Success of the International Engineering Congress

The engineers of the United States may justly be proud of the success achieved by the International Engineering Congress held at San Francisco last month. This is the third engineering congress held in connection with a world's fair in the United States, the first being that held at Chicago in 1893 and the second that at St. Louis in 1904. Those of the profession who have attended all three of these congresses will agree that the one just closed at San Francisco exceeded in importance and interest each of its predecessors. This success has been attained in the face of difficulties and discouragements wholly without precedent. The European war did indeed rob the congress of much of its international character, especially in preventing the attendance of the great number of foreign engineers who would otherwise, without doubt, have been present. It speaks volumes for the courage and nerve of the Pacific Coast engineers, to whom the success of the congress is mainly due, that they only worked the harder to make the event a success in the face of the world calamity that threatened to make shipwreck of their enterprise, as it has made of so many others.

One noteworthy fact in connection with the congress, which is unquestionably in some degree responsible for its success, is that five great national engineering societies, representing five leading branches of the profession, united in giving to the congress both moral and financial support. The sentiment freely expressed at the congress by leading members of all the societies was that the demonstration of the solidarity of the profession and of the feasibility of effective coöperation by its representative bodies in bringing about results of general benefit to the profession as a whole was in itself an achievement of great value.

Too much praise cannot be given, however, to the engineers of San Francisco, to whose self-sacrificing labor the success of the congress is chiefly due, and especially to the chairman of the Committee of Arrangements, Dr. William F. Durand, and its secretary and treasurer, W. A. Cattell. For many months these San Francisco engineers have given their time to preparations for the congress wholly without compensation other than the privilege of aiding in the success of an enterprise for the benefit of the profession. It deserves record, too, that at the very outset of the congress enterprise engineers of the Pacific Coast contributed $10,000 in cash toward a fund to meet its necessary expenses.

The profession owes a debt to these engineers of the Pacific Coast, whose energy and self-sacrifice have made it possible worthily to celebrate the completion of the nation's great engineering achievement, the Panama Canal, not only by that other great engineering achievement, the Panama-Pacific Exposition, but by a published record of contemporary engineering achievement in all branches and by an assemblage of leading members of the profession such as is seldom brought together.

Astoria Tunnel Romance

Stories of struggles with desperate difficulties are plentiful in the history of subaqueous tunneling, but few surpass in interest the narrative of events in the Astoria Tunnel work as printed in this and next week's issues of *Engineering News*. Those who take pleasure in the dramatic phases of engineering work ought not to miss this story; it reads like a romance of adventure. The courageous and resourceful builders of the tunnel, working in fissured and decomposed rock more than 200 ft. below water, proved their worth by fighting time after time against great inrushes of water, and always holding their ground. Success was almost within reach, when one Sunday morning a flow of such overpowering vehemence broke out that they had to run for their lives, while the water filled up tunnel and shaft and drowned out the pumps. Only a few days earlier the flood might have engulfed men and all, submerging the tunnel perhaps for good. But in the nick of time two safety bulkheads had been erected, which partly blocked the flow of the water. As if to keep up the dramatic sequence of the action, however, the bulkheads were only partly effective, saving the actors in the play, but failing just sufficiently to complicate the plot and make its final solution more impossible. How the story ends—how the lost tunnel was regained and the remaining work completed, making everything safe—the reader will find set forth in the article.

Two years ago *Engineering News* printed an earlier story of the same tunnel, only less absorbing than the present one. It told of the early difficulties and how by skill and persistence they had been overcome. But even while that story, announcing the "final" success, was being printed, the new and greater flood burst in. We now have the sequel to the story of two years ago.

The art of rock grouting has been advanced materially by the Astoria Tunnel work. Continuous injection of grout in remarkable volume, under very high air pressures, was the key feature of the operations. The results attained with the process speak for themselves. The necessity of closing seams in rock against high pressure and while rapid flow continues does not arise often, but when it arises the situation is grave. With knowledge of what was done in the Astoria Tunnel such situations may be faced more hopefully.

The past half dozen years have virtually created rock grouting; at least they have made its value widely appreciated. Now the process is likely to become still more important an expedient in construction.

No cost figures have been published for the Astoria Tunnel. It is obvious that the expense was great, probably exceeding very largely even the most pessimistic advance estimates. This should be well noted in connection with the general question of tunneling, and especially should it be remembered when reading about a tunnel of easy construction and low cost. More than most other kinds of construction, subaqueous tunneling ranges over very wide limits of cost, due to conditions usually

not determinable in advance. The chance of great difficulties must always be reckoned with when starting on a tunnel enterprise. They may come or they not come; but the wise engineer in his advance calculations will count in a measure on the unfavorable chances. He will not adopt the cost figures of an easy tunnel, nor those of the most difficult—like the Astoria Tunnel—but by placing his estimate somewhere between the two he will make allowance for the possibility of striking costly trouble.

A Satisfactory Alternative

In the coming November election in the State of New York the voters will be asked to pass upon a referendum authorizing the issuance of $27,000,000 of bonds to be devoted to the completion of the New York State Barge Canal. Apparently, the opposition to the canal in its entirety is as violent as ever, for there is being circulated, under the head of the "State Committee on Canal Referendum," a letter in which the addressee is urged to contribute to a fund which "will be required to properly place the matter before all the people of the State" so that the bond issue may be carried.

Now that the canal is all but completed, it would of course be the sheerest folly not to vote the sum required to finish the work, particularly as the excess is largely due to land condemnation not contemplated in the original estimate; but there appears to be a peculiarly satisfactory alternative to an adverse vote. According to the circular letter noted, in case the referendum fails the money will have to be raised by direct tax. In this case the City of New York will have to pay 70% of the total, or, as the letter puts it, "$19,000,000 by direct tax—a crushing blow to the taxpayers of the city."

Those who remember that the original Barge-Canal plan would never have carried except for the voters of New York City, will be able to see the hand of Nemesis in any such necessary tax levy.

Incidentally, the "State Committee on Canal Referendum" can afford to be more precise. It states that "the Barge Canal has cost the State of New York $100,000,000." It has cost already some $27,500,000 more. The original bond issue was $101,000,000, the Cayuga and Seneca branch issue was $7,000,000 and the terminals issue was $19,800,000. The amount to be asked for in November will bring the total to $154,800,000, not counting the interest on the bonds during construction, which already amounts to many million more.

Revising Elevated Railways

Busy city streets are not ideal sites for steel erection or reconstruction. Matters are still less ideal when not only the street traffic must be cared for but also railway traffic over the structure being rebuilt. The New York elevated-railway third-tracking, carried on under these doubly complicating conditions, takes high rank in the records of structural erection. The account of the work in this week's *Engineering News* and in the preceding issue notes that a traffic of some 300 trains each way per day was maintained over the elevated railway while the old columns were taken down and new ones placed, new main girders put in, additional track built and stations (in full service) altered and shifted.

Doing the work at all under this heavy traffic, and doing it without accident to the railway, are achievements that call for high commendation. Of equal rank is the rapid execution of the work. The contractors and the railway company share the credit for bringing about these results. A factor whose bearing on the results is likely to be undervalued is the thoroughness of the preliminary planning, which was so minute and farseeing as to reduce the actual building almost to the level of mechanical routine. The railway engineers merit a large part of the credit for the smoothness and rapidity of the operations. On the other hand, the high degree of safety which was realized stands to the credit of those who actually handled the work—the contractors.

One-fourth as many papers on the program as there were members on the registry list appears to have been the record at the International Engineering Congress held recently at San Francisco. As the congress was divided into ten sections, many of which were in session at the same time, it is no wonder that the sectional attendance was small, ranging from 150 to 30, according to the breadth of appeal of the various sections. The editorial summaries of the proceedings in last week's and this week's issues bear witness of the value of the congress, but indicate that if it is to justify all the expenditure of energy and money which it has cost, then there should be liberal subscriptions to the proceedings. These may be secured either in part—by sectional topics—or as a whole, as stated at the close of the report of the congress elsewhere in this issue. The volumes should be in every engineer's library.

Though many months must pass before the world's greatest steel arch—the Hell Gate crossing—will be reported as finished, bridge engineers will appreciate that the virtual completion is to be dated last Friday, when the cantilever half-arches were lowered to junction and the arch with its abutment thrust came into existence. The work of the day (reported in our news columns) was a real event, and while no celebration featured it, the half score of engineers who were on the ground are likely to remember it. Samuel Rea grasped the importance of the event, as shown by a congratulatory message which he addressed to Gustav Lindenthal, the engineer of the bridge, dwelling on the fact that the bridging of Hell Gate, accomplished that day, was the realization of a project born twenty-five years ago.

The broad-minded and businesslike way in which the Illinois State Board of Health is going about the selection of a chief sanitary engineer is refreshing indeed to those who are wearied with the common political methods of filling such positions and have only a little more patience with the other extreme—routine civil-service examinations. The aim of the board named and of the Illinois Civil Service Commission is to follow much the same plan as would a private employer who had an important scientific position to fill. This, combined with salary prospects commensurate with ability, should attract applicants from all parts of the country. Details of this unusual opportunity are given under News of the Engineering World, in the last part of this issue.

Letters to the Editor

Effect of Iron on Paint

Sir—I am naturally much interested in the letter published on page 613 of your Sept. 23 issue under the caption, "Does Good Iron Preserve Paint?"

The Research Department of the American Rolling Mill Co. at Middletown has, as you are aware, conducted for the past ten years perhaps the most extensive and elaborate series of tests ever instituted on iron and steel with relation to corrosion resistance. These have included exposure tests on all types of ferrous metals under a wide variety of conditions. They have also included careful observations of the behavior of paints of different types on "Armco" (American Ingot) iron and on various other sheet metals. The results absolutely verify Mr. Sanborn's statements.

Similar conclusions are drawn from the behavior of pure openhearth iron in service. It is often used with a protective coating of paint and also quite extensively as a base for painted sheet-metal signs. Experience shows that it retains the paint in a comparatively perfect condition long after the same paint on a steel base is so roughened and loosened as to be of little use.

B. G. Marshall,
The American Rolling Mill Co.

Middletown, Ohio, Sept. 27, 1915.

Hooke's Law and the Form of Stress-Strain Curves

Sir—I read with intense interest Professor Hedrick's article on a generalized form of Hooke's law, but I think there is one important point that he overlooks. In the case of the cast and worked metals the experimental loading was most likely not the only loading causing strains in the material and his empiric stress-strain relation took care of both types of strains. We have so much experimental and mathematical verification of Hooke's linear relation between stress and strain (not only for static loadings but also in the case of vibrations) that strong negative proof should be required to modify the law.

The tests on isotropic materials where the initial strain is zero have clearly demonstrated the authenticity of the law. The tests on æolotropic materials may have failed to demonstrate the law (assuming the initial strain was zero) because our coefficients were deduced from faulty theory.

For example, a tension test made on a material æolotropic in the direction of the load would probably neglect the torsional effect produced. Likewise, coefficients deduced from flexural tests based on the common Bernoulli theory may be misleading.

It would seem possible, starting with Professor Hedrick's parabolic relation and assuming Hooke's Law to hold, to ascertain the initial conditions in the material.

G. Paaswell.

New York City, Sept. 20, 1915.

How To Light a Blasting Fuse

Sir—The concluding sentence of the article, "Explosives for Driving Concrete Piles," in *Engineering News*, of Sept. 16, recalls many nervous moments of waiting for a man who is trying to get a common safety fuse to burn. In describing the proper method of lighting a fuse the article states that "this must be done quickly; hence a torch or other large flame is best." On the contrary, I believe the quickest, surest and safest method of lighting a fuse is with the ordinary friction match, lighted and touched to the fuse *while the head is still burning*. This will cause the "spit" of the fuse powder at once, without lighting the braid of the fuse, so that by the time the match head has stopped burning, one knows whether the fuse is lighted. Using a large flame, the chances are that the wrapping will light first and the "spit" of the powder will not be visible through the flame.

Splitting the fuse assists in quick, sure lighting; the split should not be longer than ¼ in. to ⅜ in. at the end and should be spread to expose the powder. I have considered it safe to light four or five fuses with length of 18 to 20 in., before seeking safety. With longer fuses a greater number may be lighted, but in firing larger numbers there is always the danger that by missing count of explosions some person may return before all charges are fired. In regard to short fuses I will affirm that other opportunities of saving time or money are generally available.

T. Ray Martin.

2172 E. 89th St., Cleveland, Ohio, Sept. 18, 1915.

Another Flat-Slab System To Be Licensed

Sir—Statements and letters have recently appeared in the technical press regarding flat-slab patent suits and the court decision rendered sustaining the Norcross patent. While this decision declares the Norcross invention to be fundamental for flat-slab construction, it should be borne in mind that a basic patent does not cover improvements that often are required to make an invention a commercial success.

As owners of an important improvement patent used in over twenty million square feet of floors already built, we have, in view of the decision rendered in the Norcross case, taken a license under that patent for the protection of our patrons, and therefore are authorized to issue licenses under both the Sinks and Norcross patents. In order that no one may unwittingly infringe or permit infringement of these patents in buildings for which they are responsible, we have issued a bulletin entitled "Flat-Slab Patents," which we will gladly send free to any of your readers upon request.

Condron Company,
By T. L. Condron.

The Monadnock, Chicago, Ill., Sept. 18, 1915.

The 977-Ft. Hell Gate Bridge Becomes an Arch

After a season of fast work in erecting steel on the Hell Gate 977½-ft. arch, New York, the American Bridge Co. placed the closing section of bottom chord on Thursday, Sept. 30. The next day, Oct. 1, the important operation of slacking off the backstays was performed very successfully, and thereby the two half-span cantilevers were converted into an arch.

The photographs herewith show how the closure chord of the south truss was set in place, and (lower view) how the structure appeared with the first continuous steel over the entire span-length. Shortly after these views were taken the north middle chord member was similarly set, and on the same day one diagonal of the middle panel was placed and bolted and drifted tight. This made the bridge ready for lowering the two half-arches to contact and slacking off the backstays completely. The successful lowering on the next day made the structure a three-hinged arch, the center hinge formed at the butting contact of the west end (left-hand end in the views) of the middle-chord member.

The top-chord members of the middle panel are being set in place as this paper goes to press. They will have no structural function for the present, but will rest in position idle, with only one end connected up, until the floor hangers and all the steel of the suspended floor-system have been set. When this stage is completed, their unconnected ends will be riveted up in a carefully devised procedure. A temporary connection will first be made by a heavy tension rod or bolt inside the chord, which takes hold of diaphragms in the closure member and the adjoining chord-member. The closure end splice-plates are blank; when the tension rod is screwed up, and thereby a connection made, strong enough to hold the blank splice immovable against temperature effects, the splice rivet-holes will be drilled and finally the joint riveted up. This changes the bridge to its final two-hinged condition. The concrete floor is to be put in after this stage; therefore the load of this concrete and of the ballast and track, the railway live-load, and temperature and wind effects will stress the bridge as a two-hinged arch, while the weight of the steel stresses the bridge as a three-hinged arch.

The center section of bottom chord weighs about 85 tons as hoisted; this is for one truss. Two 17-part falls from the two top-chord travelers lifted the piece from a scow and entered it in place. The gussets on this piece are extraordinarily large (208 in. wide) but were made in two pieces, the joint being on the vertical line through the panel point. The plates of the adjoining sections had to be spread to allow the gussets and splice plates to enter and interleave as the piece was lifted vertically into place.

The arch had built out to a separation (across the middle panel) about 1½ to 5 in. greater than the length of the closure member. As the backstays were set to hold the half-arches slightly above true position, the distance was as desired. The closure member, when entered, was bolted and drifted up full at its east end; that is, it was connected to the Astoria cantilever, and hung free at the other end, holding by the torsional resistance of the Astoria joint. The diagonal from the Astoria top chord to the free end of the closure chord was then set and bolted up, as was also the lower half of the opposite diagonal (the middle panel has crossed diagonals).

This work was completed late on Sept. 30, ready for slacking off the backstays the next day.

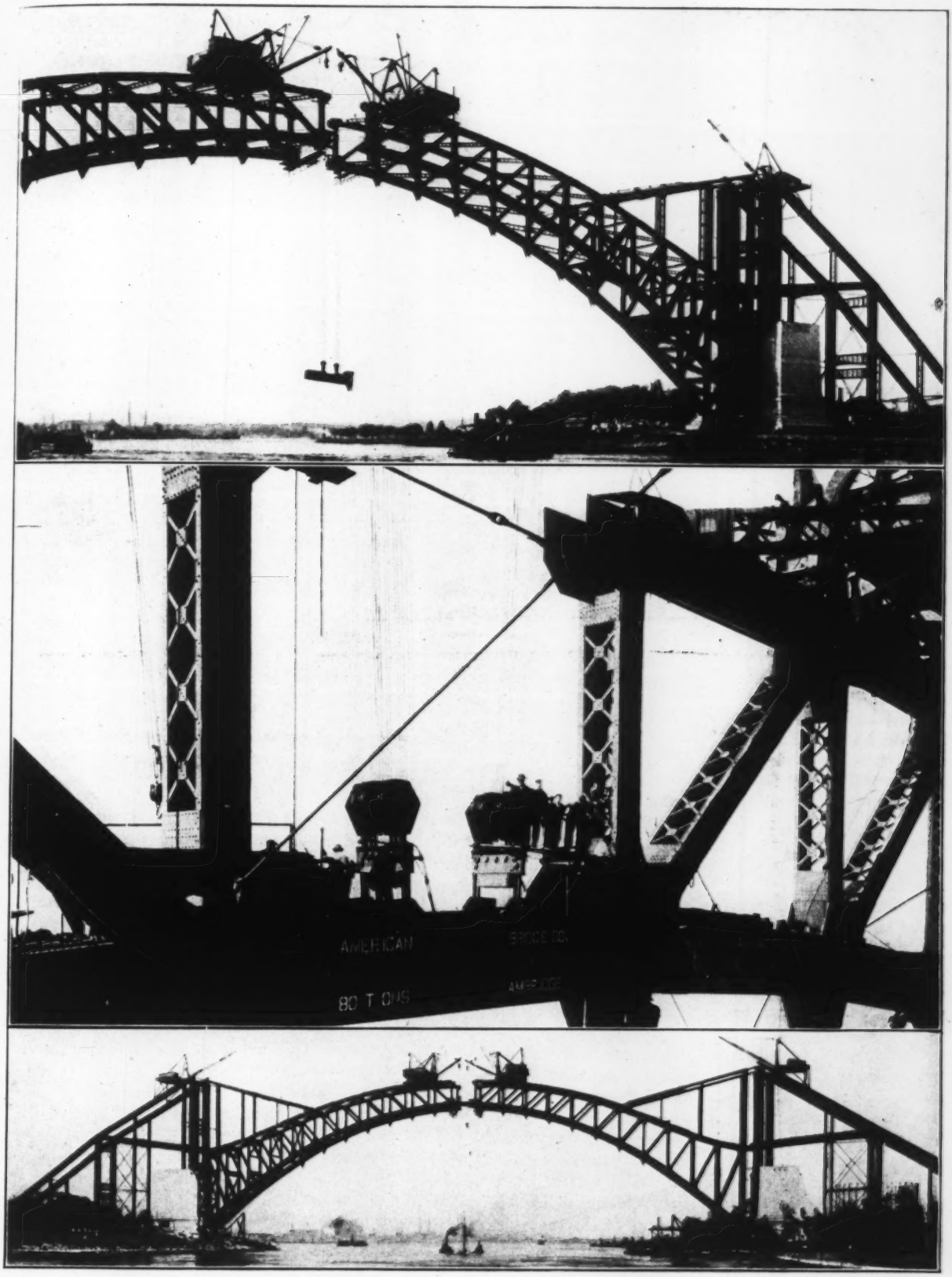
The backstay saddles rest on jacks, one per backstay or two on each bank. These are special 39-in. jacks designed for a maximum working pressure of 5,000 lb. per sq.in., giving them a lifting capacity of 3,000 tons each. Early on Oct. 1 the jacks were raised about 1½ in. to take the load, relieving the pile of ½-in. lateral plates used as blocking under the saddle. The pressure required was about 4,450 and 4,200 lb. per sq.in. respectively for the Astoria and Ward's Island sides. The jacks were lowered slowly to bring the joint at the meeting of the bottom chords into contact. In this stage it was necessary to observe closely the alignment and relative levels of the four chord ends and manipulate the four jacks to bring them into correct contact; some re-jacking was required. The total lowering in this stage was something over 2 in.

Before further lowering, the splice plates at the point just brought into contact were bolted up, to make the joint secure against any vertical shear that might develop from unequal lowering on the two sides. About 1:15 p.m. lowering was resumed, under control of an open telephone connection between the two jack stations, the crown, the two anchorage counterweights and the office. Lowering was reported on this line by both jack stations every ⅛ in. or ¼ in., and at the same time the jack pressure was given. Levels to note any settlements were read on the two counterweights, whose load of 5,200 tons (each) was being released by the backstays and coming to bear on their sills. The final pressure of about 4 tons per sq.ft. produced a mean settlement of 2½ in. at the Astoria counterweight and ¾ in. at the other.

In one-half hour the jacks were lowered about 5½ in., never differing more than ⅛ or ¼ in. (the maximum). The structure was already in partial arch condition, and safe against lifting from any possible temperature decrease. The jack pressures had decreased uniformly to 2,200 and 2,250 lb. By this time the counterweights began to show slight settlement, but as the rate was not greater than expected the jack lowering continued. The pressure then dropped at a faster rate than up to this point, and finally reached zero with slightly over 15 in. lowering, at which time the eye-bars which made the hitch between backstay and arch had become fully loose. The total time of lowering from the stage of bolting up the middle splice was 1¼ hr., a rate of 12 in. per hr.

The release of compression in the anchor struts of the backstays caused no trouble (the counterweights were mounted on rollers).

The critical operation of lowering was watched by a number of representatives of the bridge company and the railway company, among them Richard Khuen, manager of erection, J. B. Gemberling, district manager of erection, C. G. E. Larsson, assistant chief engineer, and J. Lowenstein, assistant engineer, all of the American Bridge Co.; and O. H. Ammann, assistant chief engineer, H. W. Hudson, construction engineer, S. D. Heed, assistant construction engineer, and D. B. Steinman and W. A. Cuenot, assistant engineers, all of the New York Connecting Railroad (Gustav Lindenthal, chief engineer). The operation was carried out by Daniel Burns, foreman of erectors, and H. H. Starr and Walter J. Parsons, assistant engineers.



CLOSURE OF THE 977½-FT. HELL GATE ARCH

Upper view, hoisting closure member of south truss; Astoria (east) end of bridge at right. Middle view, closure member entered into position. Lower view, the south truss of the arch making the first continuous connection over Hell Gate. Views taken Thursday, Sept. 30, 1915.

Engineering Aspects of New Orleans Hurricane

By W. H. P. Creighton*

New Orleans and vicinity experienced on Sept. 29 the worst storm on record. The wind velocities surpassed all previously observed, and the rainfall was very high. In consequence there was much destruction of minor buildings and of overhead wires and some damage from flood.

The barometer, wind and rainfall records as observed at Tulane University[1] are as follows:

BAROMETER RECORD, NEW ORLEANS, SEPT. 29

12 : 08 p.m.	29.24 in.
2 : 35 p.m.	28.99 in.
4 : 25 p.m.	28.63 in.
5 : 21 p.m.	28.22 in.
5 : 42 p.m.	28.09 in.
8 : 00 p.m.	29.00 in.

WIND RECORD, NEW ORLEANS, SEPT. 29

86 mi. per hr. for 10 min.
120 mi. per hr. for 20 sec.
66 mi. per hr. = maximum previous record.

RAINFALL, NEW ORLEANS, SEPT. 29

0.27 in. for 5 min.
0.59 in. for 10 min.
0.73 in. for 15 min.
1.11 in. for 30 min.
1.65 in. for 60 min.
2.54 in. for 120 min.
Maximum previous record, 8.2 in. for 20 hr.

On 10 sq.mi. of city streets 240,000,000 cu.ft. of rain fell in two hours. Normally this enormous precipitation could have been handled with but little delay, as the city possesses the largest and most economical low-lift pumps in the world. As a matter of fact, in the business section and main residential sections the water was off the streets almost as fast as it fell. In the outskirts and lower sections of the city the streets were badly flooded and the water was not completely removed till Saturday. This was due to backwater from Lake Pontchartrain raising the level of a canal and thereby flooding the city when its embankment was carried away, combined with the falling of wires for electrically driven pumps of the city drainage system and the presence of obstructions in one of the large canals under construction.

The falling of transmission lines either from wind pressure or the weight of falling trees caused all current to be shut off as a precaution from the street railway, light and telegraph systems. Nine thousand telephones were disabled. All the railroads were temporarily interrupted and only two have resumed approximately normal operations (Oct. 3).

Fallen church steeples, roofs, fences, buildings, sheds, house chimneys, wrecked bridges, railroad sheds, schooners, coal tows and window glass give ample evidence of the force of the wind.

What lessons can the engineer learn from this widespread disaster? We must separate the destruction caused directly by the wind from that caused through such subsidiary agents as water, waves, uncontrolled drifting barges, falling trees or flying missiles. On doing this we note that the damage done by wind is entirely unlike that done by earthquakes. Wind destruction is capricious and is single rather than widespread or general. Of ten large plate-glass windows of the same size and in the same line in a large department store each alternate glass was broken to bits and the others left in perfect condition. Only a part of the tiles are taken off a ridgepole; one chimney is overturned and a dozen apparently similarly situated are left untouched.

A careful survey of all the destruction will show that there is a fairly satisfactory reason for each failure. Many church steeples did not fall and those that did were either old or square and of limited cross-section. Comparatively few smokestacks fell. Brick walls were overthrown, but the mortar is easily taken from the bricks that fell. Open sheds, carbarns and docksheds suffered, but they were of flimsy construction and when lifted from the ground easily collapsed. Thus the Dumaine dockshed, a steel structure 600 ft. long and 50 ft. wide was lifted clear of its inadequate footings on a wharf and deposited 30 ft. to leeward of its original position, with columns unbroken but badly twisted at the junction of the roof truss and columns. Trees were overturned, but their root system was either small or rotten; the Louisville and Nashville R.R. lost a large part of a well-constructed bridge, probably because an uncontrolled barge was slammed upward against the floor. The Gulf Beach railway system will have to rebuild a large portion of its roadbed, but the wash of the waves is responsible as the direct agent.

The destruction in the closely built sections of the city is insignificant. The largest and tallest buildings have trivial damages. Even the grain elevators on the river-front are operating as usual. The greatest destruction is among the flimsy structures in the outskirts and environs of the city.

To sum up, no well-designed engineering structure received more than trivial damage, hence the present factor of safety is more than ample, especially where buildings are closely set.

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[1]Compare with Weather Bureau records on opposite page.

Meteorology of West Indian Hurricane, Sept. 22-Oct. 2*

Between the northeast trade winds of the North Atlantic and the southeast trades of the South Atlantic, which on crossing the equator become southwest winds, there lies a belt of relatively low pressure, light variable winds and calms and vapor-laden air, commonly referred to as the "doldrums" and occasionally called the "meteorological equator." This belt of calms separates the general wind circulation of the Northern from the Southern Hemisphere, and it advances northward and retreats southward with the sun, but lags behind the sun—that is to say, the sun reaches its maximum north declination in June, while the "meteorological equator" is farthest north in August. This belt is an ideal breeding ground for tropical cyclones or hurricanes, but it is only when it lies farthest north that the right-hand deflecting effect of the earth's rotation becomes effective and gives the air that moves toward some local area, where the air has become superheated, a gyratory motion. Hence it is found that hurricanes are most frequent during the months of August and September. Why they should be more frequent in some years than in others is not understood.

On Sept. 22, 1915, in the doldrums in about Lat. 15° and Long. 64°, the forecaster on duty at the central office

*Report furnished by United States Weather Bureau, through District Forecaster E. H. Bowie, Washington, D. C.

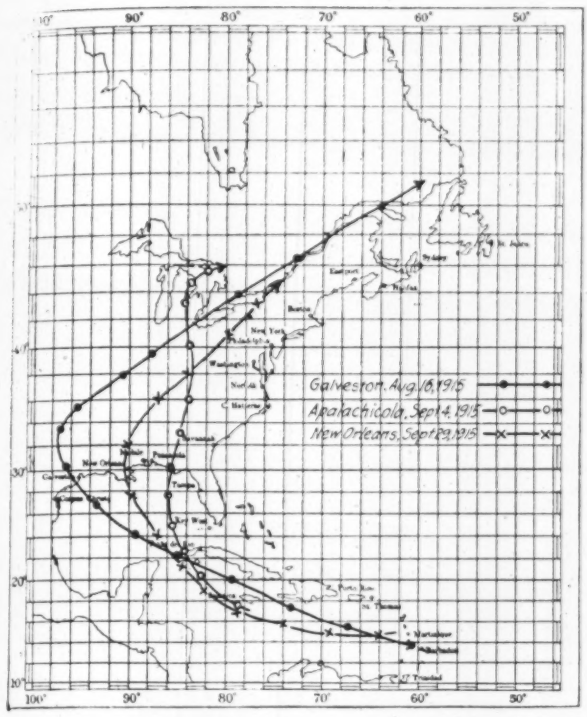

FIG. 1. PATH OF THREE RECENT HURRICANES THROUGH EASTERN UNITED STATES

at Washington, D. C., detected the first signs of the formation of a hurricane, although no reports were had from that immediate region. This storm then began to manifest its presence by the changed wind directions and the clouds and their peculiar movements as is usually the case when a hurricane is somewhere near. Advices concerning this storm were sent on the 22d to West Indian stations and shipping bound for West Indian waters. The deduction that a storm was in process of formation was confirmed by later reports. And day to day thereafter until the storm had passed inland near the mouth of the Mississippi River, and thereafter rapidly lost intensity, advices and warnings were issued for the guidance of shipping and the residents of the Gulf Coast regions. The track of this hurricane is shown on the chart in Fig. 1,

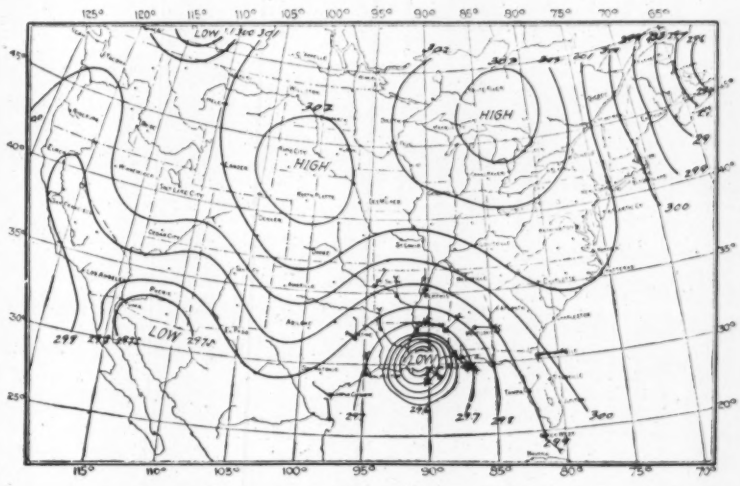

FIG. 2. WEATHER MAP OF THE UNITED STATES, SEPT. 29, 1915

RECORD OF OBSERVATIONS AT NEW ORLEANS, LA., SEPT. 29, 1915

Date	Time: 75th Mer.	Time: Local (Standard)	Barometer, Reduced to Sea-Level	Thermometer, (Dry)	Wind: Direction	Wind: Velocity	Wind: Max Since Last Observation	Wind: Direction	Precipitation	State of Weather
29th	8 a.m.	7 a.m.	29.54	78	E	40	40	E	0.40	Raining
29th	10 a.m.	9 a.m.	29.44	74	N.E.	40	42	N.E.	0.72*	Raining
29th	Noon	11 a.m.	29.30	74	N.E.	44	52	N.E.	1.86	Raining
29th	2 p.m.	1 p.m.	29.10	76	E.	62	64	N.E.	4.02*	Raining
29th	4 p.m.	3 p.m.	28.90	76	E.	56	64	N.E.	5.64*	Raining
29th	5.50 p.m.	4.50 p.m.	28.11	(Lowest pressure during storm)						
29th	8 p.m.	7 p.m.	28.26	76	S.	24	*88	S.E.	7.32†	Raining
30th	8 a.m.		29.58	74	S.W.	18	36	S.E.	0.08	cloudy

*Maximum wind velocity for 5 minutes; the extreme velocity was 130 miles per hour.
† Amount since 8 a.m.

which also shows the track of the hurricane that passed near Galveston on Aug. 16, 1915, and the one of lesser importance that passed inland near the mouth of the Apalachicola River on Sept. 4, 1915. It is unusual, in fact unparalleled, that three hurricanes should reach the Gulf Coast within a period of approximately six weeks.

The New Orleans hurricane was equal to and possibly surpassed in intensity the one that occurred at Galveston in August. At New Orleans on Sept. 29, 1915, the lowest pressure, reduced to sea level, standard gravity, etc., was 28.11 in., the lowest reading ever recorded at a Weather Bureau station; and the extreme wind velocity

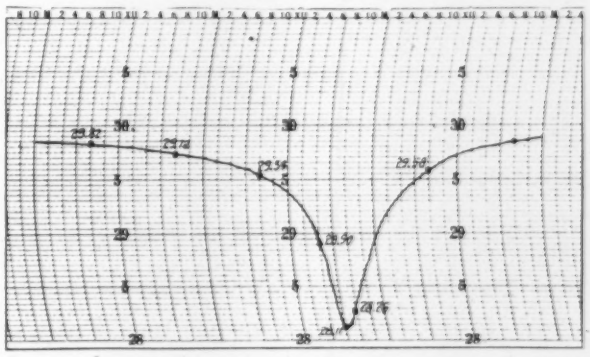

FIG. 3. BAROMETRIC RECORD AT SEA LEVEL, NEW ORLEANS, SEPT. 28-29, 1915
Trough of curve at 6 p.m., Sept. 29

was (approximately) 130 mi. per hr. from the east. Fig. 3 shows the sea-level pressure at New Orleans during the coming and passing of the storm. This barogram was constructed from reports received by telegraph, and no doubt will differ in minor particulars from the automatic record. Fig. 2 is the weather map of 8 p.m., Sept. 29, approximately 2 hr. after the center of the storm passed to the north immediately west of New Orleans. The pressure at New Orleans was then rising. The continuous lines on this chart are drawn for each 0.10 in. of pressure, except in the immediate vicinity of the storm center, where the gradient is so steep that it is not possible to show the lowest closed isobar. The arrows show the direction of the wind at the various stations within the storm area; the number of feathers on the staff of the arrow indicates the force of the wind (Beaufort scale) at the time of the observation.

The table contains what is known of the meteorological conditions at New Or-